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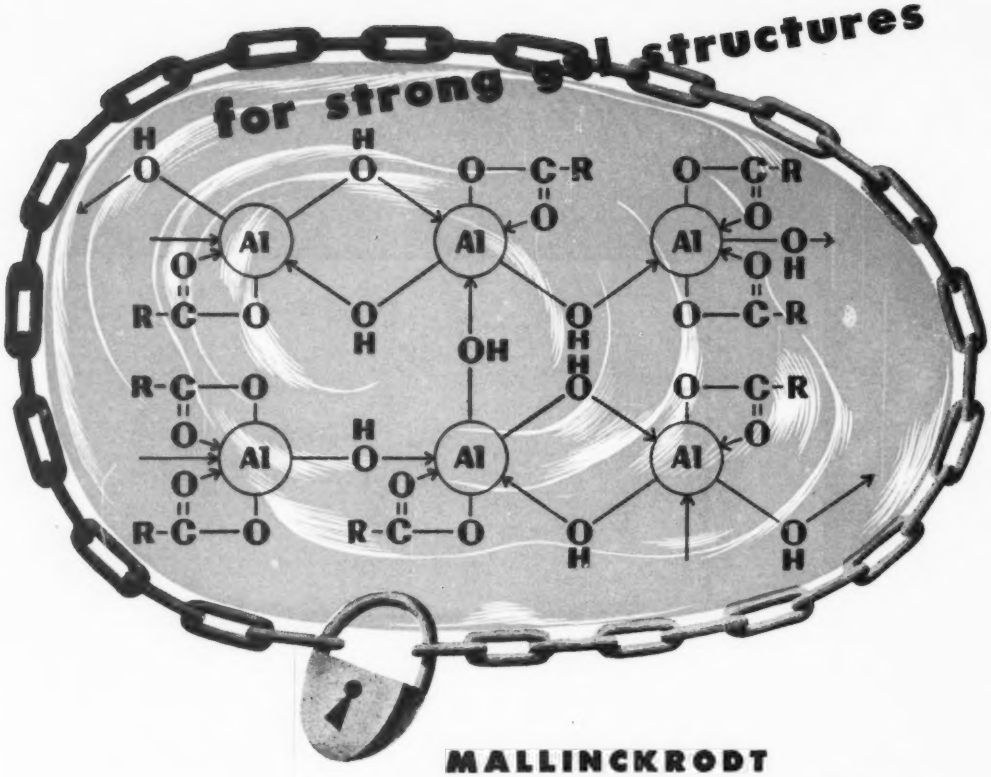
NATIONAL LUBRICATING GREASE INST NLGI



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*Dean, W. K., "The Structure of Aluminum Greases", *Inst. Spokesman*, XV No. 6, Sept., 1951, p. 12.

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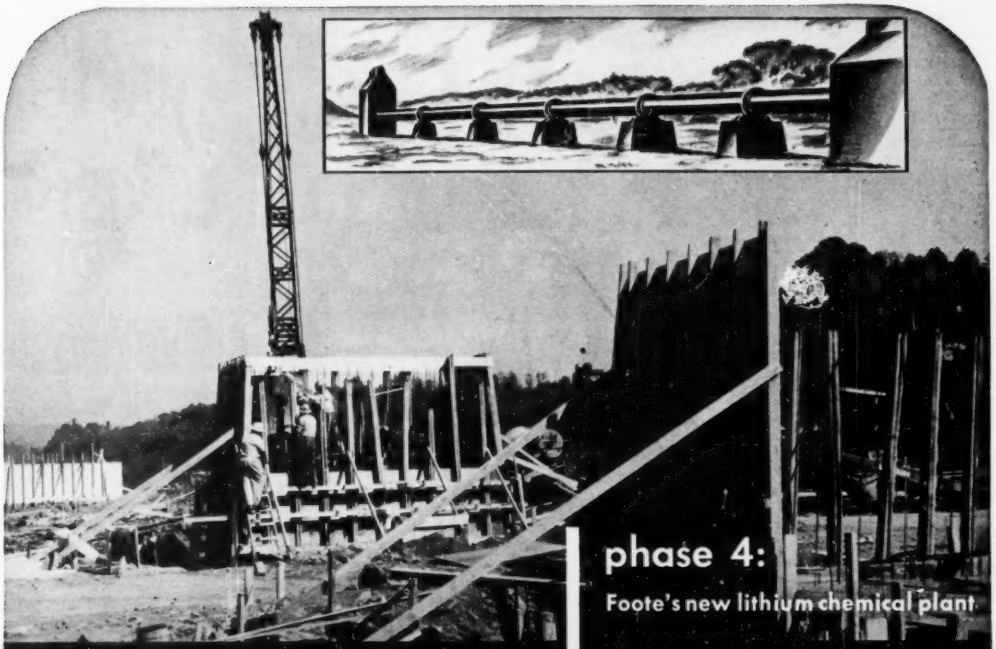

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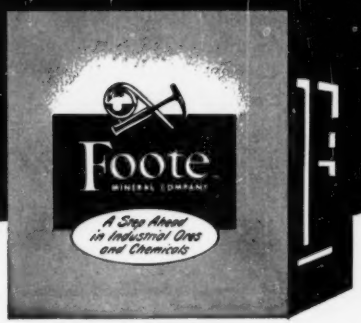

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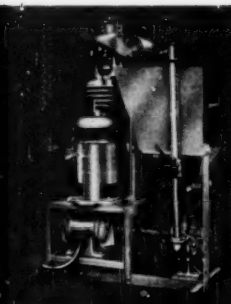

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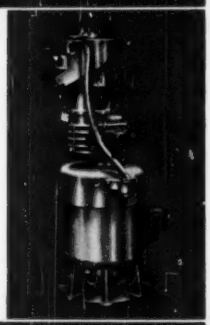

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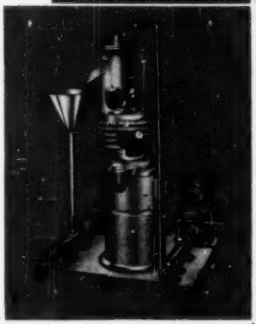

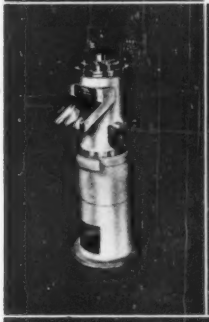

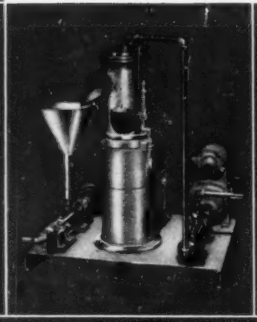

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ABOUT THE COVER

Pictured on the cover is a part of the three-meter grating spectograph in the laboratories in the Mallinckrodt Chemical Works.

This versatile instrument is an important research and analytical tool which is of great value in the determination of traces of impurities in chemical raw materials and finished products. Although not used for routine analysis in the production or quality control of metallic soaps it is useful in research and provides information which may be extremely difficult to get by other methods. It is an example of the kind of equipment and facilities chemical manufacturers accustomed to producing fine chemicals can bring to bear on problems connected with the production of the more technical products, such as the aluminum stearates for lubricating grease manufacturers.

Shown in the photograph are the chamber in which the sample is burned in an electric arc, and some of the electrical equipment which controls the temperature of the arc. At the temperatures in the arc each of the metallic elements emits light of specific wave lengths which is then resolved into bands by the diffraction grating. The bands are recorded on a photographic plate and are as characteristic of the element as a finger print is of an individual. Their position determines what elements are present and the intensity of the bands determines how much of the element is present.

President's page

by W. Wayne Albright, President, N L G I

LUBRICATING GREASES AND THE AMERICAN WAY OF LIFE

Too often the average American fails to realize the role of lubricating greases in our American way of life. His only direct contact with "grease" may be when he takes his car for a periodic visit to the corner gas station for a chassis "lube" job.

He is probably convinced of the importance of regular chassis lubrication because of what both the maker of his car and the grease maker tell him. He knows that failure to grease his car regularly is soon made known to him by stiff operation, premature wear and, ultimately, looseness and wobble that tell him that his car's under parts need attention.

Does he realize that lubricating greases play just as important a role in thousands of applications that surround him? His vacuum cleaner, his refrigerator, the motor that powers his home workshop all may depend on grease lubrication to keep bearings protected and shafts freely turning. Many such applications, of course, employ bearings in which the grease is sealed for the life of the device and the user does not know that lubricating greases are being used.

Even more important, the average American should be aware of how lubricating greases help to keep the production machines of industry operating on schedule, economically and dependably. Farm machinery which helps to produce the very food he eats, needs vital lubricating grease to protect and keep free from excess friction its many moving parts. American mass production methods depend now more than ever before on machinery kept in motion with proper lubrication.

Far, far back in history, when the first wheeled cart creaked and groaned, it was discovered that animal fats prevented crude wooden axles from literally burning up. The story of man's achievements from that time has been one of continual effort to improve things that move, rotate or slide. With improvements in machines came the necessity for adequate lubrication and the development of a number of exactly-suited, specialized lubricating greases.

So, the average American who is the chief beneficiary, should realize the important part played by manufacturers and users of grease lubricants in developing new and complex types of lubricating greases for the varied and exacting demands of present-day machinery. It is part of our job as members of NLGI to remind him of our part in the American way of life.

today and tomorrow

". . . raw material available in the U. S. to support a long range, greatly expanded industrial use for lithium chemicals."

by H. C. Meyer, Jr., and J. Fentress, Foote Mineral Company, Philadelphia, Pennsylvania

Abstract

Some fifteen years ago, if a grease was required for a very high temperature application, such temperature resistant greases were available. And, if a grease was required for a mechanism operating in an atmosphere of considerable moisture, water resistant greases were available. But, if a mechanism was exposed to both high temperature and moisture, suitable greases which would stand up under both conditions were generally unavailable.

Then along came lithium greases which combined moisture resistance and heat resistance! Today, these so-called "all-purpose" or multi-purpose greases are the fastest growing grease types in point of popularity.

Unfortunately, however, lithium metal or its compounds are almost equally popular for ceramics, glass, aluminum products, humidity control systems, certain types of storage batteries, and officially unconfirmed but rumored top secret military uses. As a result, lithium has been in short supply. Actually, the ore from which lithium is refined is plentiful, but processing is cumbersome because 120 tons of ore must be processed to get one ton of lithia. By mid-1953 however, the world's largest lithium plant will be completed at Sunbright, Va., thus easing, if not completely solving, the present shortage.

Introduction

In "Life" magazine, and articles in the press, lithium has been tied to hydrogen bombs, atom bombs, atomic power

HOLES ARE DRILLED in which will be placed dynamite in preparation for breaking up rock.

LOADING sticks of dynamite is routine for these experienced mine hands who are preparing to blast another section of pegmatite rock.

EVEN THIS LARGE SHOVEL cannot handle the "big boys" in the background which are being split with pneumatic drills prior to being trucked to the ore crusher.

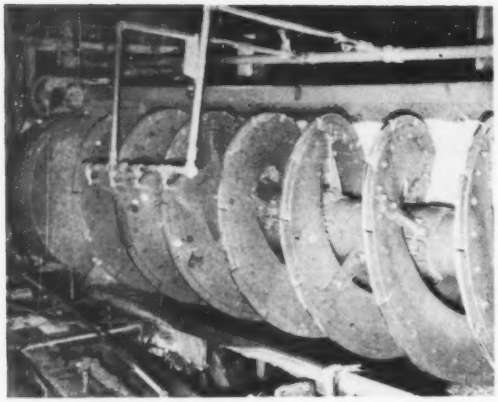
THIS AERIAL VIEW of the Foote Kings Mountain plant clearly shows the ore crushing units behind the mill building and the mounds of lithium-bearing spodumene in the drainage bins (center foreground).

The series of pictures on the first three pages show how lithium is produced from a hole in the ground to the finished product:

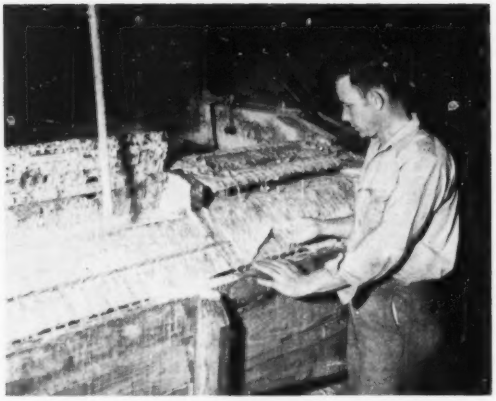
ORE is dumped into a hopper at a primary crusher. Conveyed by a series of belts, ore is carried from the crusher to the gyratory.

AT THE GYRATORY ore is reduced to gravel size and screened. Oversize pieces are carried back to be recrushed.

THE PEBBLE MILL further crushes ore to 20 mesh before separation of spodumene from the pegmatite.



A SPIRAL SEPARATOR conveys ore from ball mills to flotation cells.



IN A SERIES OF FLOTATION CELLS, heavier spodumene is separated from frothy "gang" material which is skimmed off and processed for the recovery of important by-products.

p'ants and a host of secret uses. All, incidentally, officially unconfirmed. No headlines are needed to confirm the fact that you in industry have not been getting the lithium you require. Therefore, it was believed that a frank discussion of what is going on in the lithium industry would be of aid to the members of the NLGI in planning their future operations.

Is it physically and economically possible to produce enough lithium for established commercial uses? Where do the actual and hypothetical military uses fit into the picture? To answer these questions we must examine the foundations of the lithium industry, raw materials, chemical processing capacity, and the economics of the market for lithium. The present uses of lithium will also be examined for their effect on future markets.

Raw Materials

The lithium industry starts from an ore. Although there are almost two dozen known lithium ores or source materials, only three are believed to be of current or future economic importance. These are:

A. Spodumene — $Li\ Al\ Si_2O_6$ — 4-8% Li_2O

B. Lepidolite — $Li\ K\ Al_2\ F_2\ Si_3\ O_9$ — 2-4% Li_2O

C. Brine Residues — $Li_2\ Na\ Po_4$ — 15-20% Li_2O

Because of its availability to the United States market and its relatively high lithium content, it seems probable that expansions of lithium production will be based on spodumene. The major occurrences of this ore in the United States are in the Kings Mountain area of North Carolina and in the Black Hills of North Dakota. Other deposits in Maine, California and New Mexico are known. It has also been reported in the provinces of Manitoba and Ontario, Canada. Indicated reserves at the major United States deposits are in excess of 1,000,000,000 lbs. of lithium hydroxide equivalents.

Lepidolite is not currently a major source of lithium for chemical production although it has been used extensively for this purpose in Europe. It is, however, well suited to many ceramic applications where the combination of lithium, potassium and fluorine is valuable for its fluxing action. Therefore, the future availability of lepidolite will affect the ceramic demand for lithium chemicals. The major operating deposits are near Karabib in Southwest Africa, where several individual claims are reported to contain in excess of 100,000 tons of ore. The ore is widely distributed and has been worked in Germany, Portugal, Madagascar and in California, New Mexico and South Dakota.

The only brine residues currently being worked are at Searles Lake, California. Here, the mixed alkali brines are removed, the lithium is concentrated as an insoluble mixed alkali phosphate. The residues are a desirable raw material for chemical production, but availability is geared to the demand for the major constituents of the brine.

In the past, when the chemical demand for lithium ores was a few carloads a year, hand quarrying and sorting operations by individual prospectors were adequate and indeed the only economically feasible production method. Today, however, high volume open pit mining with mechanical classifying is needed to produce the volume of ore required.

Typical of such mechanized mining and ore processing are the operations at Kings Mountain, North Carolina. The deposits here are described by the United States Bureau of Mines as "the largest known group of deposits in this or any other country". The spodumene occurs in pegmatite dikes, long seams of feldspar running through the country rock. There are frequent surface outcroppings of these seams, but since these are badly weathered, it is necessary to strip the dirt and weathered ore down to solid rock. This is done with typical earth moving equipment such as power shovels and bulldozers. The seam may now be blasted to break it up and free it from the surrounding rock. The mixed ore is loaded by rock shovel into trucks which haul it to the primary crusher. The 2' to 3' lumps are crushed to 2" size here; then, in a secondary gyratory mill to about ¾"; and then, in wet ball mills to 20 mesh. The ore goes from the ball mills to spiral classifiers where heavy minerals are separated. The mixed ore is then concentrated and pumped to flotation cells where the spodumene is recovered.

As currently operated, this plant will produce 25,000 tons

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PETROLEUM CHEMICALS DEPARTMENT
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WORLD'S LARGEST LITHIUM PLANT, under construction at Sunbright, Virginia, is shown in a general view.

of ore per year. This tonnage of ore when processed is equivalent to more than one-half million pounds of lithium hydroxide monohydrate per month. It should be noted that one of the major problems in lithium processing is the large volume of raw material which must be handled. In mining, six tons of mixed rock yields one ton of ore. In chemical processing, considered next, twenty tons of ore yield one ton of lithium oxide.

Chemical Processing

The reactions employed in chemical processing of ore are not essentially complex. They may be conveniently divided into two classes; those involving acid solubilizing and those involving base exchange. In either case it may be advantageous to heat the ore to increase both reaction rate and the differential solubility of the lithium oxide portion of the ore.

In the acid process the ore is treated with strong mineral acids, typically sulphuric or hydrochloric to yield the corresponding lithium salt.

In the base exchange process the ore is treated with alkali or alkaline earth metal compounds which will yield a soluble lithium compound when the metal replaces the lithium in the ore. Typical compounds would be chlorides, sulphates or oxides.

$$Li\ Al\ Si_2\ O_6 + HX \longrightarrow Li\ X + Al\ X + Al_2O_3 + SiO_2$$

$$Li\ Al\ Si_2\ O_6 + MX \longrightarrow Li\ X + M\ Al\ Si\ O_6$$

When the first effluent is a chloride or sulphate other lithium compounds are commonly prepared by reaction; first with soda ash to yield slightly soluble lithium carbonate and then with lime or the appropriate acid to yield lithium hydroxide or a lithium salt.

The equipment required is not particularly specialized, but due to the volume of raw materials handled it is large. Also since the processing residue is an alumina silicate of little value, waste disposal can be a major problem.

Markets

The current major commercial demand for lithium chemicals comes from the following industries:

1. Ceramics and Glass
2. Lubricating Grease
3. Metallurgical
4. Humidity Control
5. Alkaline Storage Cells

There are also a number of minor uses which in the aggregate total approximately 15% of the market.

Market surveys made as late as 1950 indicated that in 1954 demand would exceed capacity and accordingly, expansion plans were made on the basis of this timetable. The Kings Mountain operations shown were started in 1951 to allow for this expansion. However, by the beginning of 1952 a number of accelerating factors were affecting lithium chemicals market. As you are well aware, these accelerating factors served to make even those optimistic predictions of 1950 antiquated.

For example, in ceramics there has been a steady trend toward replacement of lead with lithum to obtain harder finishes, lower firing temperatures and better working properties. However, this normal pattern of a slowly rising demand for lithium was greatly accelerated as the price of lead increased and availability decreased. Further, when the porcelain enamellers were forced to lighter gauge steel

INDUSTRIAL WATER is supplied to Foote's lithium plant at Sunbright by a man-made lake covering about 15 acres.

ALREADY??

YES - - already they are making reservations for 1953 NLGI ANNUAL MEETING

Edgewater Beach Hotel
In Chicago
October 26-28, 1953

that wou'd not stand the higher firing temperatures of the older, conventional enamels, demand for lithium for these low temperature enamels increased. The same low melting-high fluidity properties also enabled glass producers to expand their output. It is important to note that the use of lithium gave higher production from the same manufacturing units at less cost.

In the case of grease, rising labor and equipment costs placed an ever increasing premium on productivity and equipment life. The service and simplicity of use obtained with lithium greases caused a rapid expansion in their use. Natural'y, as the market expanded, the competitive factor became increasingly important, further accelerating growth of demand. Consumer acceptance and the reduction in specialized products manufactured are certainly indicative of the economic soundness of the use.

The prime function of lithium chemicals in the air conditioning field has been in humidity control. As natural gas pipelines made this fuel available to an increasing area, gas fired conditioning units found an expanded market. In the industrial field, as installations in new plants for production of synthetic fibres, antibiotics, food and a host of other humidity sensitive materials came into operation, the demonstrated advantage of these systems led to their installation in older plants with resulting additional increase in demand for lithium salts.

In the metallurgical field the prime use of lithium compounds is in aluminum welding and brazing and magnesium alloys. The use of these metals has been growing steadily and with it the use of lithium compounds. However, when the expansion of aluminum and magnesium production facilities made it apparent that in the near future these metals would be abundant while copper would continue to have limited availability at ever increasing cost, the trend toward the use of these light weight metals was even further increased. Fabricators advise us that, in most cases, the switch resulted in at least equal performance at lower cost.

The use of lithium in alkaline type electric storage batteries was probably the first major industrial use. This use has been relatively stable. Even here the continued high level of industrial activity has caused unexpected growth. A quarter century of service has certainly established the economic validity of this use.

In the meantime, the demand for lithium for the lesser industrial uses such as in plastics, pigments, bleaches, as an intermediate in organic reactions and a host of others has increased apace. The only field of decreasing activity has been in lithium chemicals as pharmaceuticals, a use which has not been industrially significant for about 15 years.

Conclusion

It is certainly true that one of the primary causes for the unexpected increase in demand for lithium chemicals was the impact of the defense program. However, even if there were no direct defense uses for lithium compounds it is probable that lithium would currently be in short supply. It was the direct defense uses that caused lithium chemicals to be placed in DPA Group 1, those materials the supply of which

GREASE MANUFACTURERS

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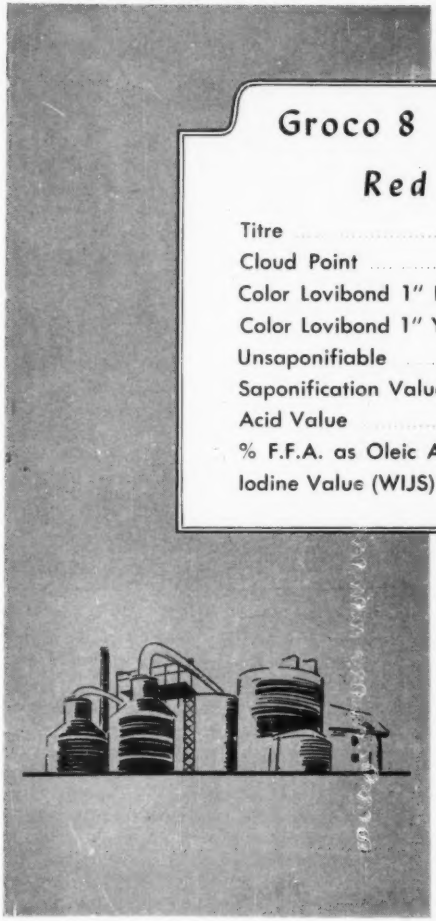

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Cloud Point	46°	-	49°F.
Color Lovibond 1" Red	4	-	8
Color Lovibond 1" Yellow	20	-	40
Unsaponifiable	2.0% max.		
Saponification Value	196	-	199
Acid Value	195	-	198
% F.F.A. as Oleic Acid	98	-	99.5
Iodine Value (WIJS)	88	-	92

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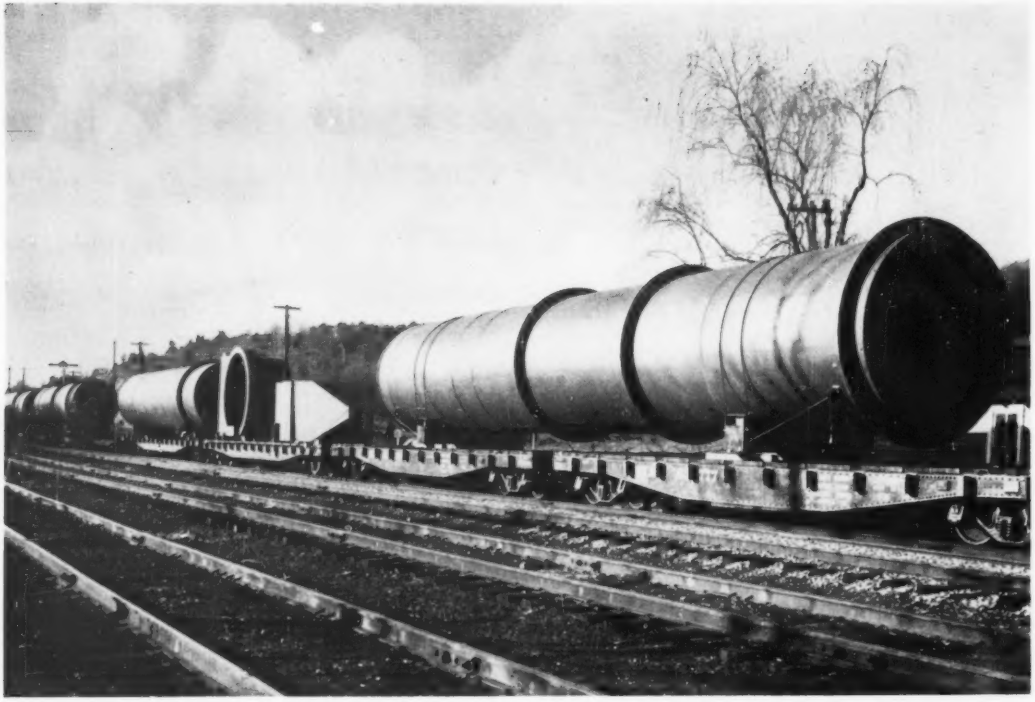


SECTIONS OF A 340-FOOT KILN arrive at Sunbright.

is insufficient to meet military and essential civilian demands. Not too much can be said as to quantities and applications for defense. You are, of course, familiar with the use of military greases. Other uses include airplane de-icing, low temperature batteries, carbon dioxide absorbents, jet engine tail pipe enamels and signaling devices. Finally, we should tentatively add to this list the unconfirmed uses that presently command such notoriety.

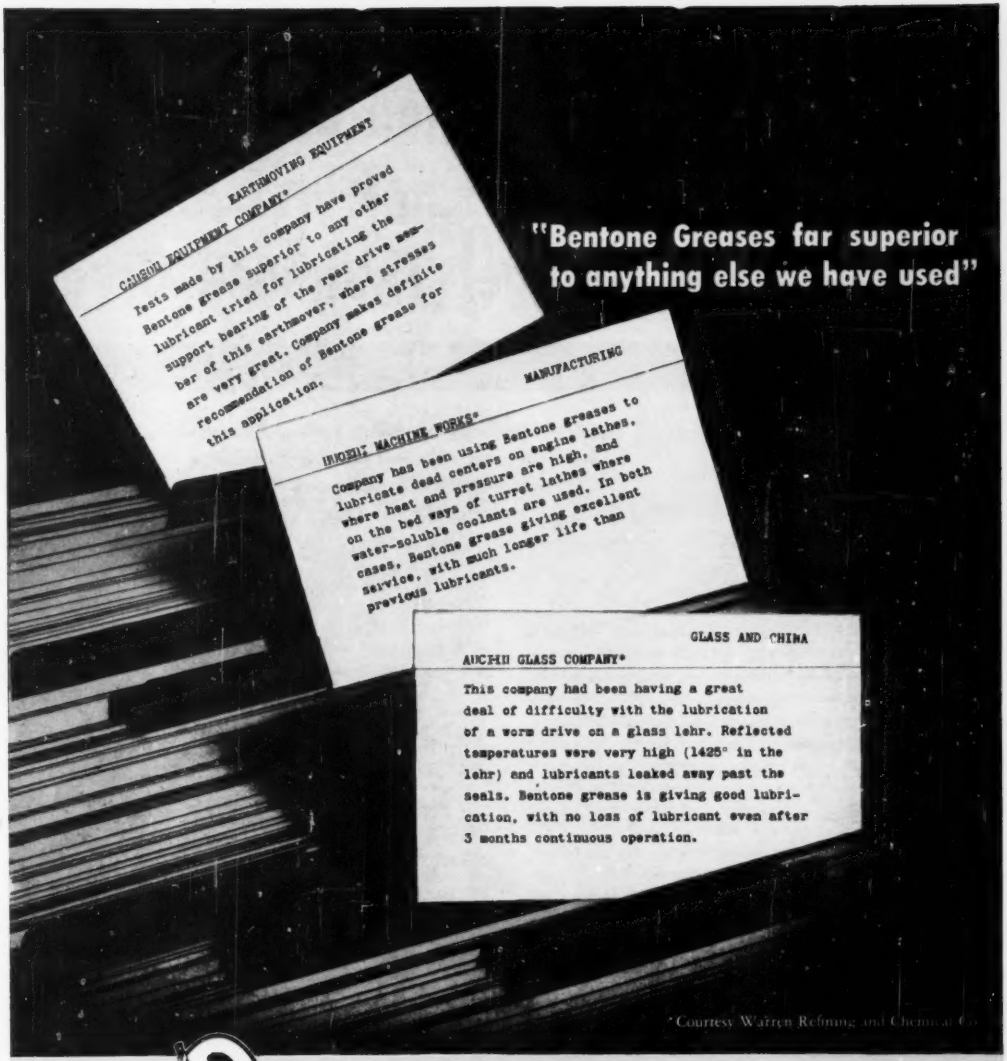
The only answer to the problem is, obviously, increased chemical production capacity. Such capacity is being installed. At Sunbright, Virginia, the world's largest lithium plant is being erected. This plant, situated on 130 acres of land in Scott County, Virginia, is on the main line of the Southern Railway and on U. S. Highway No. 23. The site was selected for its nearness to one of the important process raw materials and because of a readily available supply of cheap coal for fuel. Abundant process water is assured from a nearby fifteen-acre man-made lake. Labor in this rapidly growing tri-state area of Virginia, Tennessee and Kentucky is in good supply with many workers already experienced in chemical plant work. Spodumene concentrates are easily and economically shipped from the Kings Mountain area about 150 miles away.

At the Sunbright plant the ore is ground with other raw materials in mills capable of handling 1,000,000 pounds per day and fired in a large cement type kiln. The kiln products are digested freeing lithium chemicals from by-products. The lithium solutions are then sent to the chemical processing building for further purification. The finished products are packed and stored in the warehouse building awaiting shipment.

Although this plant, as built, will more than double this country's total capacity for lithium chemicals, the original designs have provided for subsequent expansion at a minimum cost of time and capital.

It is expected that by the middle of 1953 the chemical processing capacity of the entire industry will be three times the present capacity and the mining capacity will have undergone an equivalent expansion.

In conclusion, there is sufficient raw material available in the United States to support a long range, greatly expanded industrial use for lithium chemicals. The demand is sufficiently diversified to insure that no single consuming industry will be forced to support the demand. Industry capacity is being expanded to meet this demand. In short, from the consumer's point of view the supply picture in the near future, will be most favorable and it will continue to be so.


EARTHMOVING EQUIPMENT
CAMDEN EQUIPMENT COMPANY*
Tests made by this company have proved Bentone grease superior to any other lubricant tried for lubricating the support bearing of the rear drive member of this earthmover. Where stresses are very great, Company makes definite recommendation of Bentone grease for this application.
"Bentone Greases far superior to anything else we have used"
MANUFACTURING
Company has been using Bentone greases to lubricate dead centers on engine lathes, where heat and pressure are high, and on the bed ways of turret lathes where water-soluble coolants are used. In both cases, Bentone grease giving excellent service, with much longer life than previous lubricants.
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This company had been having a great deal of difficulty with the lubrication of a worm drive on a glass lehr. Reflected temperatures were very high (1425° in the lehr) and lubricants leaked away past the seals. Bentone grease is giving good lubrication, with no loss of lubricant even after 3 months continuous operation.
*Courtesy Warren Refining and Chemical Co.

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Wherever the going is rough, where extremes of temperature and pressure make severe demands on a lubricant, greases made with "Dutch Boy" Bentone 34 are proving themselves to be exceptional in mechanical and chemical stability, metal adhesion, water resistance and long-continued lubricating properties.

For information on greases made with

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a radically-new, non-soap gelling agent

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For many years the grease maker has thought primarily in terms of soaps as the thickening agents used in greases. Recently more work is being done on synthetic gelling agents which have the appearance of a very finely divided powder but when mechanically mixed with oil in the proper proportions at ordinary temperatures have the ability to form grease like structures with remarkable properties.

Preparation and Properties of Silica Aerogel-Thickened Greases

by E. C. Milberger and Lorraine J. Swatik
Chemical and Physical Research Division
The Standard Oil Company (Ohio)
Cleveland, Ohio

Abstract

Silica aerogel-thickened greases are thickened lubricants wherein a finely divided silica is used as the gelling agent instead of soap. The silica content is non-abrasive as shown by laboratory tests and by field performance. These greases are characterized by extreme ease and reproducibility of preparation at ordinary temperatures and with conventional mixing equipment. When properly compounded with suitable additives, they are shown to possess water resistance, consistency stability at high temperature and to working, excellent oxidation resistance, and low bleeding tendencies. Their exceptionally flat temperature versus consistency curve frequently permits the use of softer grades than would be required with soap-type greases. To date, greases of this type have been successfully used in many service applications and show promise for multi-purpose duty.

A DISCUSSION on the subject of silica aerogel greases should first include a description of the silica gelling agent used. However, since the preparation and nature of silica aerogel are will described in the literature[1] only a brief description will be given.

One commercial form of this material is a free flowing grayish-white powder. It is extremely light and fluffy with an apparent density of three to four pounds per cubic foot. Various measurements made on this material have led to the following proposed structure[2]. The primary particles, of about 8 Angstroms diameter, are of B-crystobolite. These link together in random spacing and orientation into fibers, described as primary agglomerates, one dimension of which is in the range 25 to 35 Angstroms. From these, a secondary agglomerate is formed as a result of an intertangling of fibers. Spacings or voids between fibers range from 50 to 400 Angstroms with an average of about 250. This secondary agglomerate can possess practically any over-all dimension. In the commercial material the agglomerate particle size is 3 to 5 microns.

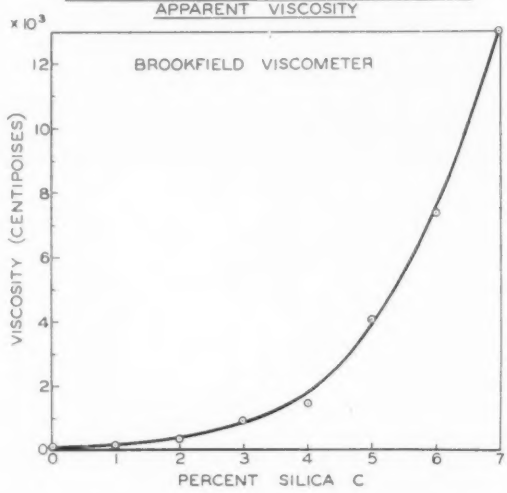
Data will be presented for two different modifications of this material, designed Silica A and Silica C.[3]

[1] *S. S. Kistler, J. Phys. Chem. 36, 52 (1932).*

[2] *J. F. White, Private Communication, Monsanto Chemical Company, Boston 49, Massachusetts.*

[3] *Material supplied by the Monsanto Chemical Company, Boston 49, Massachusetts.*

FIGURE 1
EFFECT OF SILICA C CONCENTRATION ON APPARENT VISCOSITY



Preparation of Silica Greases

General

Preparation of the greases simply involves the incorporation of the finely divided solid gelling agent into a liquid lubricant. The silica disperses readily into oil with simple spatula mixing. The addition of silica to a liquid lubricant gives an increase in viscosity which changes rapidly with increasing concentrations of silica with a fairly abrupt transition to a gel state, as shown in Figure 1 for Silica C. The apparent viscosity increases slowly up to about four weight per cent Silica C after which the curve rises abruptly. This correlates well with a visual examination of the individual silica-oil mixtures. That is, a distinct development of yield point or body is evident between the samples containing 3 per cent and 5 per cent silica.

Because of the auto-gelling tendency of silica aerogel, the mixing technique had to be of a type which would work or knead the entire mixture. Two methods of preparation have been employed in the laboratory. The first was simple addition of the gelling agent into oil with spatula stirring, followed by 1000 strokes in the ASTM motorized worker. This method under standardized conditions was adopted as a control in determining relative gelling efficiencies of different shipments of silica. Some of the results obtained are shown in Table I. The four check determinations shown for silica sample No. 1 are an indication of the repeatability of this procedure. The results from the nine different samples are indications of the uniformity among different samples of silica.

The second method utilized the scraping blade and contra-rotating paddle action of a triple-action ice cream freezer. Two such mixers of two-quart and three-gallon capacity, motorized and equipped with constant temperature baths, were used, and closely approximated results obtained later in pilot plant and plant mixers. A typical grease preparation proceeded as follows: The base oil blend was placed in the mixing vessel and brought to the proper temperature. The silica was then added incrementally as rapidly as it could be incorporated into the oil, and mixing was continued until the desired penetration was obtained.

TABLE I

GREASE PREPARATION RESULTS

Spatula Mixing and 1000 Strokes Working

Silica A Samples	ASTM Penetration
1	319
1	312
1	316
1	319
2	327
3	307
4	335
5	315
6	313
7	312
8	304
9	305

250 Solvent Extracted Neutral and 8% Silica A Used

300 gm. Total Batch Size

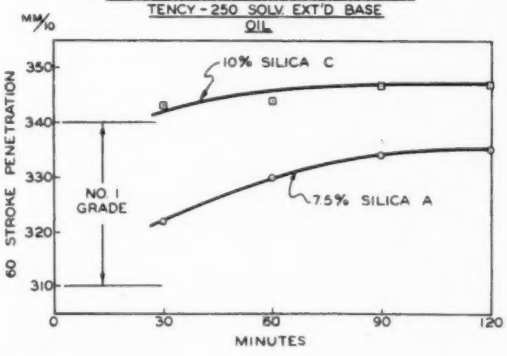
Processing Variables

Using paddle mixers of the type described above, the only process variables which appeared significant were mixing time and temperature. Sufficient mixing time is needed to obtain a homogeneous mixture. Immediately after the final addition of silica the penetration measurements obtained were at a minimum and then gradually approached an equilibrium value. Typical results for a grease containing Silica C and one containing Silica A are shown in Figure 2. The grease yield difference in terms of penetration between the two silicas is apparent.

The effect of the second process variable, mixing temperature, is illustrated by Figure 3, showing the worked penetration obtained on grease samples of identical base oil composition, prepared at different temperatures, with both Silicas A and C. Both silicas show a decrease in yield with increasing

FIGURE 2

EFFECT OF MIXING TIME ON CONSISTENCY - 250 SOLV EXT'D BASE OIL



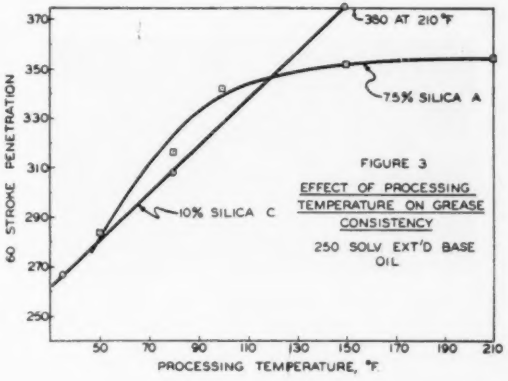


FIGURE 3

EFFECT OF PROCESSING TEMPERATURE ON GREASE CONSISTENCY

250 SOLV EXT'D BASE OIL

FIGURE 4

EFFECT OF SILICA CONCENTRATION ON YIELD

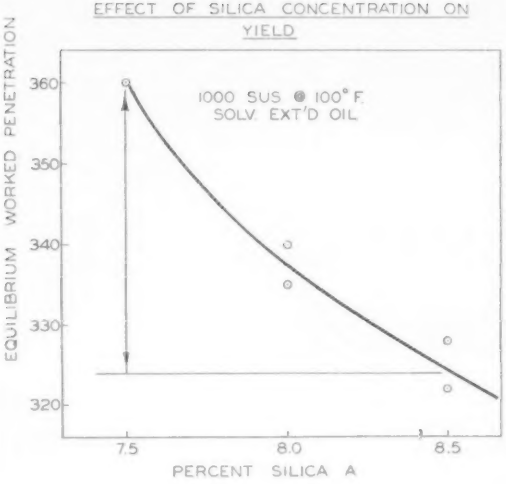


FIGURE 5

EFFECT OF BASE OIL VISCOSITY ON GREASE YIELD (SILICA A)

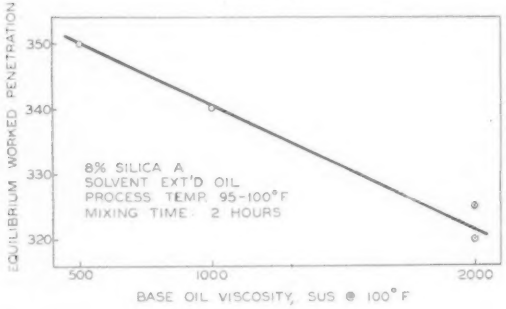
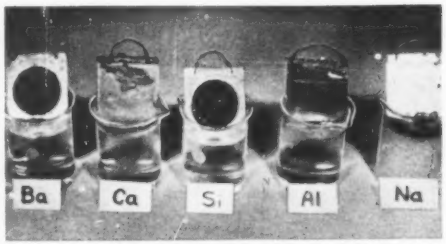


FIGURE 6



COMPARATIVE WATER RESISTANCE CHARACTERISTICS AFTER 30 MINUTES BOILING WATER

process temperature, but Silica A levels off at the higher temperatures making it more desirable.

Additional variables may be introduced if subsequent processing steps are used. Essentially, additional processing consists of high shear techniques such as colloid milling or homogenization. Such supplemental treatment has a marked effect on increasing grease consistency, and reducing bleeding as will be shown later.

Composition Variables

Composition variables may be studied from two points of view: first, the effect of composition variables on grease yield and second, the effect of these variables on grease properties. The following variables which reflect on grease yield will be discussed: gelling agent concentration, base oil viscosity, and nature of the base oil.

The effect of ge'ling agent concentration is shown in Figure 4. One weight per cent difference in silica content, in this range, is equivalent to approximately 35 penetration units.

A wide variety of petroleum as well as synthetic lubricants were investigated as suitable stocks for silica greases. It was found that silica aerogel could successfully gel almost any type of hydrocarbon lubricant. Slightly better grease yields are experienced when conventionally refined oils are used instead of solvent extracted materials. The effect of viscosity of one base oil type on grease yield is shown in Figure 5. As expected, increasing base oil viscosity results in increasing grease yield.

Laboratory Performance Results

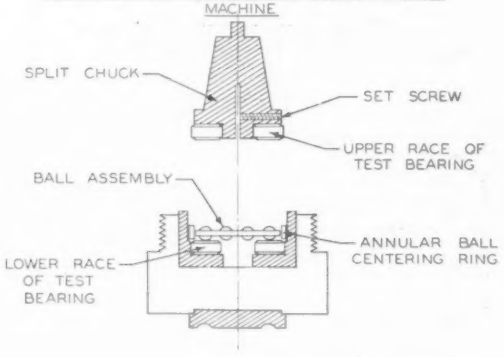
Water Resistance

Since a silica-oil mixture rapidly disintegrates into its components when exposed to water, a water resistance improvement was required. This was eventually accomplished by suitab'e additives.

During the development work to attain suitable water stability characteristics, two test procedures were employed. One simply involved the immersion of a uniform stenciled grease disk on a stainless steel plate into boiling water for 30 minutes. Conventional soda, lime, and aluminum greases

FIGURE 7

TEST BEARING HOUSING FOR SHELL 4 BALL MACHINE



TEST BEARING: ANDREWS FT-1 THRUST BEARING

TABLE II

WATER STABILITY

Grease Gelling Agent	Static Stability	Dynamic Water Stability Original	600 Strokes 100% H_2O	% Water Emul.	Comment
Silica A Additive 1	Pass	162	>300	100%	Emulsion inverted to O/W
Silica A Additives 1 & 2	Pass	185	121	50%	Free water remaining, grease-like character
Lithium hydroxystearate	Pass	129	146	>50%	Free water-greaselike
Barium soap	Pass	141	191		Free water-greaselike

fail under these conditions as is evident in Figure 6. A stabilized silica grease and a barium grease were satisfactory.

A second dynamic test involved mixing equal quantities of grease and water by working 600 strokes in the ASTM worker. A Shell microcone penetration was obtained on the original grease sample, and a subsequent measurement obtained on the resulting grease-water emulsion. Observations were made as to emulsion type formed, either w/o or o/w, and on the possible presence of unemulsified water. Field experience indicated that for universally satisfactory performance, it was necessary for a grease to be satisfactory in both tests. The water stability of a number of greases is shown in Table II. This test demonstrated that additives which stabilized silica greases to boiling water did not necessarily prevent emulsion inversion, since the first silica grease shown, which was stable in the boiling water test, continues to emulsify with water until inversion occurs with resultant destruction of the grease structure. The performance of the fully stabilized silica grease shown in Table II is comparable to lithium and barium grease. This silica grease emulsifies with a limited quantity of water after which no further water is taken up.

Wear Data

One of the laboratory wear tests utilized a modification of the Shell Four-Ball Machine. An Andrews FT-1 ball thrust bearing was used to replace the four balls as required in the conventional test.

This bearing was held in a specially designed housing, details of which are shown in Figure 7. Wear was followed by weighing the upper and lower races of the bearing before and after the test. In most cases the test greases were applied only to the balls in the ball-retaining ring. Test time was varied, while the load was kept constant at 20 Kg. which is approximately 55 per cent of the rated load of the bearing at the speed of the Shell four-ball machine.

Results obtained from a number of samples of grease made with Silica C compared with the base oil used and a soda base grease are shown in Table III.

The bearing weight losses are extremely low. Comparing the last two sets of data, at 100 and 325 hours, it is evident that the wear with silica grease is very comparable to that shown by the soda base grease.

TABLE III

MODIFIED SHELL 4-BALL

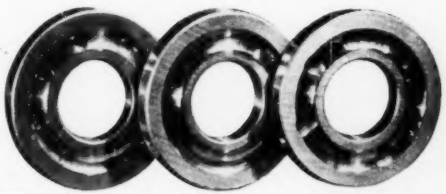
THRUST BEARING WEAR TEST

Grease	Time Hours	Change in Bearing Weight, Mg. Top Race	Bottom Race
Base Oil	4	—1.9	—1.9
Silica C	4	—0.2	0.4
Silica C	27	0.5	0.0
Silica C	100	—0.6	—0.3
Silica C	325	—0.4	—0.1
Soda	100	—0.9	—0.3
Soda	330	—0.3	0.0
Silica A	100	—0.2	0.3

Load: 20 Kg.

Andrews FT-1 thrust bearing
(80 lb. load rating at 1800 rpm)

FIGURE 8
FAFNIR FRICTION OXIDATION
TEST BEARINGS



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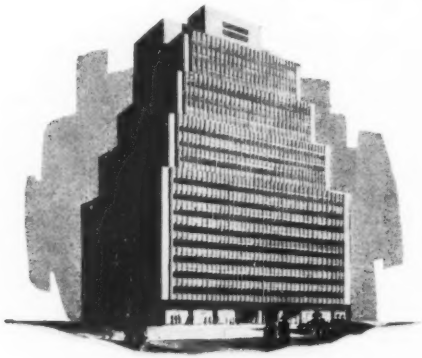

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Silica A grease performance in the Fafnir Friction Oxidation test was evaluated. Figure 8 is a photograph[4] of test bearings which are representative of the results from four runs of each grease tested. The end bearings were lubricated with what was described as a good ball and roller bearing grease. The contrast between these bearings and the center bearing, which was lubricated with a grease thickened with Silica A, is obvious.

These laboratory data indicated that the silica used as a gelling agent possessed no abrasive characteristics. Since these tests were made, results from the field have fully confirmed this view.

High Temperature Resistance

Silica greases maintain their gel characteristics at elevated temperatures. The base oil may ignite or distill but no melting has ever been observed in any case where working has not occurred. A comparison between soda soap and Silica C thickened greases, prepared from the same base oil, demonstrates this extreme consistency stability at elevated temperatures as shown in Figure 9. Between 80° F. and 300° F. the penetration of the Silica C grease is essentially unchanged whereas the soap thickened grease softens markedly. As a result of this behavior, the primary emphasis was placed on the development of a No. 1 grade silica grease, which would possess at room temperature and retain at elevated temperatures the same consistency shown by heavier soap-base greases at elevated operating temperatures. The Silica A grease in Figure 9 typifies the result: uniform workable consistency throughout a wide temperature range.

This temperature characteristic of silica grease is somewhat idealized, however, since the data shown above were obtained under static conditions. Field experience indicated that high temperature in connection with working results in wide differences in consistency stability in depending upon the presence of additives, or type of silica used. A test used to evaluate these changes proceeded as follows: A 150-ml. beaker approximately two-thirds full of grease was heated in an aluminum block furnace to an equilibrium temperature of 400° F. with occasional stirring. The grease was then allowed to cool to room temperature by standing undisturbed overnight. After the sample was vigorously stirred, a penetration measurement was obtained, using the Shell microcone, and this value was compared with the penetration obtained on the original grease.

The performance of a number of conventional soap base greases under these conditions was determined. The results obtained compared with a Silica A and a Silica C grease are shown qualitatively in Table IV. Under these test conditions the conventional greases are understandably unsatisfactory. The two silica greases, however, exhibit an entirely different behavior. Both appear to be unchanged in appearance while hot, but after cooling and stirring, the grease prepared from Silica C had softened beyond the range of penetrometer measurement and the grease prepared from

[4]*Courtesy of Mr. Pope, Eastman Kodak Company, Rochester, New York.*

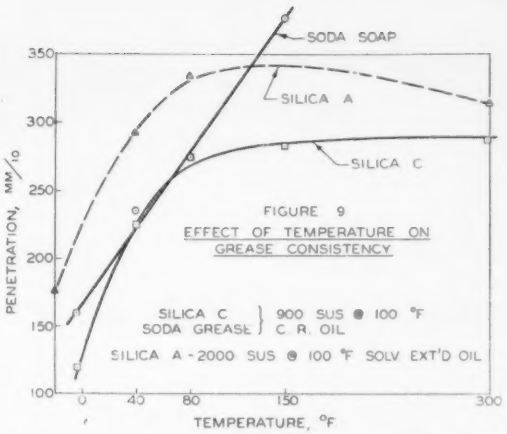

FIGURE 9
EFFECT OF TEMPERATURE ON GREASE CONSISTENCY

TABLE IV

HIGH TEMPERATURE STABILITY OF VARIOUS GREASES

Grease	Appearance Hot (400° F.)	After Cooling
Aluminum	Very gummy and soft	Hard and lumpy
Soda	Liquid	Like art gum eraser
Soda-Lime (AN-G-15)	Liquid	Separation of oil and soap
Silica C[1]	Unchanged	On stirring—liquefies
Silica A[1,2]	Unchanged	On stirring softer, but still retains grease structure

[1](Greases stabilized to pass static water test)
[2](Original Shell Penetration—153
(Final Shell Penetration—246

FIGURE 10
HIGH TEMPERATURE STABILITY

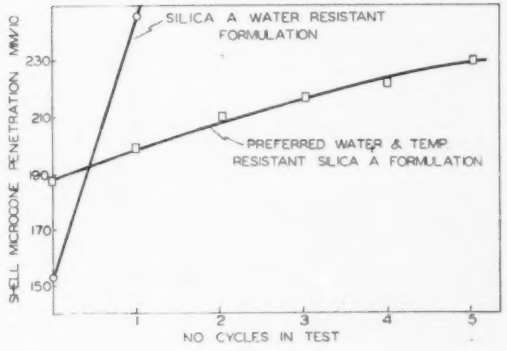

TABLE V

10,000-STROKE WORKING STABILITY OF PREFERRED SILICA A FORMULATION

Grease[1]	Processing	ASTM Penetration 0	60	2500	5000	7500	10,000	△ Penetration 0-60	60-10,000
Grease 1	Normal—100° F.	319	334	327	324	325	323	15	—11
Grease 2	Higher Process Temp.—150° F.	335	342	327	319	324	316	7	—26
Grease 3	Process Temp., 250° F. (Homogenized after cooling)	267	319	333	335	338	342[2]	52	23

[1]Preferred Formulation
[2]Penetration after standing 20 hours—298

Silica A had softened though still retaining measurable grease consistency. Although the Silica A grease was better than the grease prepared from Silica C, field data again indicated that, in many applications, additional stability was required.

The test described above was used to evaluate various methods for improving high temperature resistance. In order to obtain a greater degree of delineation, the beaker test was modified by repeating the heating and cooling cycle as long as measurable grease consistency was retained. Changes in penetration versus number of cycles were followed, and the improvement achieved by proper additive selection is evident in Figure 10. The steeply rising curve is representative of many formulations which possess otherwise satisfactory grease characteristics. The second curve presents the high temperature behavior of an improved formulation which, on the basis of this test, possesses satisfactory high temperature consistency stability. In addition this grease composition exhibits excellent water stability in the two laboratory tests previously discussed. The attainment of satisfactory high temperature and water resistant characteristics in this formulation provided the necessary requisites of multi-purpose duty. Unless otherwise indicated, the remaining discussion of laboratory evaluation will be on this improved silica grease composition.

TABLE VI

SHELL ROLL TEST RESULTS

(4-Hour Test)

Grease Type	Shell Penetration Initial	Final	△ Penetration
Aluminum	122	275	153
Lime	167	202	35
Barium	72	158	86
Barium	126	259	133
Lithium	158	147	—11
Soda (Wheel Bearing)	99	147	48
Silica A	162	191	29
Silica A[1]	181	171	—10

[1]Dynamic water and high temperature stabilized (Preferred formula)

Mechanical Stability

Mechanical stability of silica grease is very good. This performance is exhibited in the motorized ASTM worker and in the Shell roll test. Results from the first test are shown in Table V. The composition of all three greases shown is identical. Processing conditions were varied, however, with resulting differences in 10,000-stroke working stability. Grease No. 1, prepared at 100° F., shows excellent mechanical stability with a net change in penetration of 4 penetration units from 0 to 10,000 strokes. A similar change in penetration is evident with Grease No. 2 which was prepared at 150° F. The higher process temperature appeared to result in an initial decrease in grease yield, i.e., higher unworked penetration for a given amount of silica but the subsequent worked penetration values agreed closely with Grease No. 1. Grease No. 3, prepared at 250° F., required additional high shear processing to regain grease consistency. A laboratory model two-stage Manton-Gaulin homogenizer working through an over-all 5000-pound pressure drop was employed. The mechanical stability on this product exhibits a rapid penetration increase in the first 60 strokes working, after which the consistency change is relatively small. The worked material tends to regain consistency on standing.

Shell roll test results are shown in Table VI. The preferred silica formulation prepared at 100° F. is very similar to lithium grease in this test, both showing a consistency increase with working. In comparison with the other soap base greases shown, the mechanical stability of silica greases is evident.

Oxidation Resistance

Oxidation stability of these greases is excellent under the conditions of the Norma-Hoffman oxidation test. The preferred silica grease formulation, which contains an anti-oxidant, lost 0 pounds pressure after 100 hours. Even simple water-resistant grease formulations which do not contain anti-oxidants are extremely stable. However, an anti-

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TABLE VII

EFFECT OF SUPPLEMENTAL PROCESSING METHODS ON GREASE BLEEDING

(Silica A — Base Oil Viscosity 750 SUS @ 100° F.)

Process	ASTM Penetration 0	60	△ Penetration	Bleeding Gms./Wk./25 Lbs.
Paddle Mixer Alone	300	313	13	4.3
Cornell Homogenizer	278	297	19	3.1
Morehouse Mill	262	285	23	0.5
Lancaster Micromill	283	308	25	1.0
Manton-Gaulin Homogenizer	263	275	12	1.4

oxidant is used since these greases are susceptible to improvement by anti-oxidants. For example, in one test, an uninhibited grease lost 5 pounds in 196 hours and the same formulation with an inhibitor lost 5 pounds in 353 hours and after an elapsed time of 960 hours recorded only a 13-pound pressure drop. The effect of an anti-oxidant on other grease properties is generally negligible.

Oil Separation or Bleeding

Bleeding characteristics of silica greases vary over a wide range depending first on the test method employed. One such test[5] employing screen wire cones and elevated temperature storage consistently gave very low bleeding values for silica greases compared to various soap base greases. On the other hand these same silica greases bled more oil than soap base greases under the conditions of the Herschel grease press technique. In addition, small samples of silica greases stored for long intervals at room temperature exhibited little bleeding whereas larger quantities bled more. Also in at least one case a grease composition which in all laboratory tests bled profusely was declared to be outstanding for its absence of bleeding in the field.

In any event, experience indicated that obvious bleeding in manufactured packages, such as 38-pound pails, is undesirable from a sales viewpoint. Therefore, a bleeding test was devised which closely simulated actual storage conditions. A six-inch conical depression was formed on the surface of 25 pounds of grease in a 38-pound pail. Bled oil was pipetted

[5] *Procedure F-4i, AN-G-25, April, 1946.*

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3148 ROANOKE ROAD

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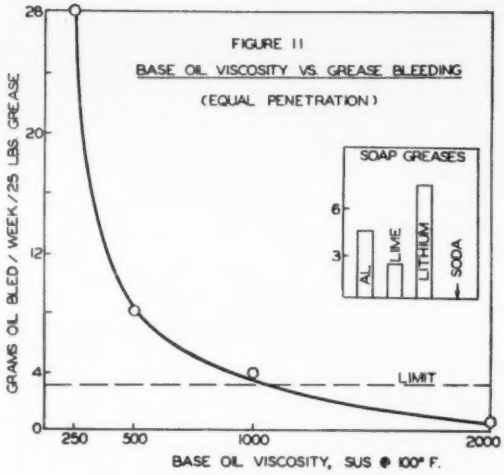
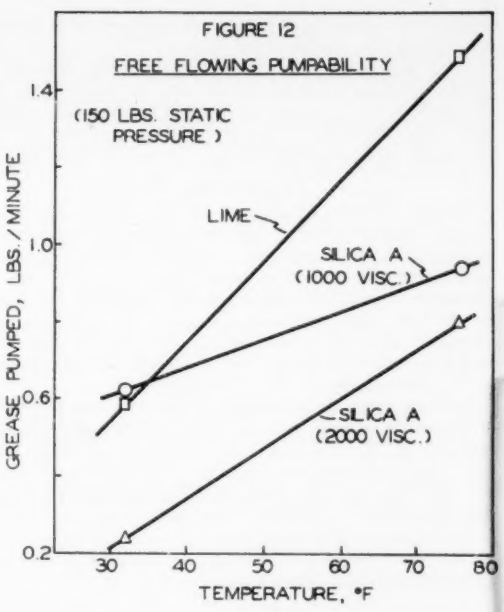


from the apex of the depression at weekly intervals for a minimum of three weeks' storage at room temperature. Acceptable limits were established with conventional soap base greases, resulting in a specification of 3 grams or less of bled oil per week.

Silica greases which meet this bleeding specification can be prepared by certain composition and/or processing alterations. An example of the former is the effect of a change in base oil viscosity as shown in Figure 11. The specification is attained when base oil viscosity is more than approxi-



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mately 1000 Saybolt at 100° F. A comparison with a number of soap base greases is also shown.

When greases are prepared with lower viscosity base oils, satisfactory bleeding characteristics may be obtained by a variety of additional processing methods, as shown in Table VII. All of the finishing processing methods increased grease consistency and decreased bleeding.

Pumpability

Relative pumpability characteristics of two silica greases versus a lime soap grease were determined at two test temperatures, 32° F. and 76° F. A double stage pump was used with a static back pressure of 150 pounds. Free flowing and restricted flow experiments were conducted on each grease. The soap base grease and one of the silica greases contained oil at 2000 SUS at 100° F. The other silica grease was prepared from 1000 second oil. Results obtained from the free flowing test are shown in Figure 12.

All three greases were pumpable at the lower temperature but the 2000 viscosity silica grease was slow. This grease was also the heaviest with a penetration of approximately 301. The lime soap grease had a penetration of 330 and the 1000 viscosity silica grease, 310. As is evident from the figure, however, both silica greases show a smaller change in delivery rate with temperature than does the soap base grease. The difference in base oil viscosity in the two silica greases produces a marked change in pumpability.

Field Performance

Various formulations of silica aerogel grease have been tested under field conditions for several hours. In the critical job of wheel bearing lubrication, silica greases have performed very satisfactorily. An early field sample successfully lubricated wheel bearings in a 10-ton Mack tractor for 60,000 miles. Later tests in this equipment have gone 100,000 miles. Conversely, other tests failed in 30,000 miles. From the evidence available it appears that silica greases like others perform best in this service when care is exercised to prevent overpacking.

Other successful field applications, for the sake of brevity, are listed below:

1. Chassis lubrication
2. General ball and roller bearing applications
3. Foundry ladle trunnion bearings
4. Phonograph turntable bearings
5. Textile spinning reels
6. Cam followers
7. Kiln car bearings
8. Farm equipment
9. Worm gear — radar antennae
10. Outdoor playground equipment
11. Shaker screens
12. Ring gears — mixing vessels

Summary and Future Possibilities

A silica grease has been developed which possesses the following characteristics:

1. Ease and reproducibility of preparation
2. Water resistance
3. High temperature consistency stability

4. Oxidation resistance
5. Mechanical stability

These are requisites for a multipurpose lubricating grease. Several unique properties plus an ever-widening field experience indicate that silica greases will have a useful and important future.

Acknowledgment

The authors wish to express their appreciation to the Standard Oil Company of Ohio for the release of this information and to the following technical personnel who have substantially contributed their efforts in supervisory, experimental, pilot plant, and field test functions: Dr. E. C. Hughes, Dr. F. Veatch, Mr. R. Clark, Mr. R. D. Croft, Mr. F. Hostetler, Mr. R. Morse, Mr. J. M. Musselman, Mr. C. P. Nunley, Mr. R. I. Potter, Mrs. Charlotte Gaddis Sheridan, and Mr. D. R. Switzer.

Discussion of

'Preparation and Properties of Silica Aerogel-Thickened Greases'

By Wilbur L. Hayne, Jr.
Research Department
Standard Oil Co. (Indiana)
Whiting, Indiana

The paper of Mr. Milberger and Miss Swatik is welcome because it formally introduces silica aerogel as a promising thickener for grease. The authors have devoted much detailed work and study to the preparation, properties, and performance of silica greases. They have done an excellent job of presenting work on a subject new to the NLGI agenda.

The first question raised when one mentions the use of silica in a lubricant is, "Doesn't it cause excessive wear?" The results of our investigation of this question check those of the authors; no excessive wear was found with silica thickeners. Data were obtained on the Shell 4-ball wear apparatus and the Navy gear-wear tester. In each of these tests wear was comparable to that observed with conventional soap greases. In the CRC 10,000-rpm 250° F. ball-bearing grease tester, the performance time of the silica grease was better than that for good soap greases.

Our laboratory investigation of processing techniques, thickener requirements, leakage, and oxidation characteristics confirms, for the most part, the results of the authors. Grease samples containing eight per cent silica and prepared over a three-roll mill or through a colloid mill showed only a small oil loss in leakage tests. More silica is usually required when additives are present. Oxidation tests on silica greases of the multipurpose type, prepared with either acid-treated or solvent-extracted oils, gave pressure drops in the range of one to three pounds in the 100-hour test. Some amine oxidation inhibitors caused an objectionable color change, apparently because of a reaction between the inhibitor and trace amounts of impurities present in some of the silicas.

As discussed by the authors, sufficient water resistance and mechanical stability at elevated temperatures can be imparted to the silica greases by the proper selection of additives. Some loss of mechanical stability may occur during extended periods at elevated temperatures, but this structure change apparently is not sufficient to cause lubrication failures.

An important requirement for a multipurpose grease, in addition to those mentioned by the authors, is that it allay corrosion in the presence of moisture. The silica greases we examined were poor in this respect. Grease-coated steel panels exhibited large areas of rusting in short-term humidity-cabinet tests. Ball bearings lubricated with silica greases rusted on drying after one hour in the ANG-5a water-resistance test. Protection of roller bearings packed with silica greases was unsatisfactory in a static free-water corrosion test. Extended service tests on wheel bearings and chassis lubricated with these greases gave evidence of rusting. The addition of rust inhibitors commonly used in soap greases did not satisfactorily improve this deficiency.

The storage and handling of silica are likely to present problems different from those of conventional grease-making materials. Because of the low bulk density of the silica, large storage facilities would be necessary. The material is readily air-borne and may create a health hazard unless special methods are introduced for charging the grease-making equipment. A possible solution to these problems may be found if the silica can be supplied with some oil present.

In the future, silica-thickened greases may assume an important position in the lubrication field. The further development of these greases will be followed with interest by all of us.

Technical Committee

Chairman T. G. Roehner, Director of the Technical Service Department, Socony-Vacuum Laboratories

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Organization of the Subcommittee on Manual of Test Methods and Definitions of Terms Peculiar to the Lubricating Grease Industry has been completed and the membership is the following:

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R. R. Uhrmacher, Panther Oil & Grease Manufacturing Co.

The Joint Committee on Lubricating Greases for Railroad Antifriction Journal Bearings met on December 10, in New York City. The minutes of the meeting will be sent to the members of the NLGI Technical Committee soon after they have been approved. In the meantime, it may be of interest to give some of the high-points:

1. Final action was taken on fifteen of the chemical and physical tests listed in the minutes of previous meetings. Those left pending are mentioned below.
2. A survey will be made of available data showing the extent of correlation between evaluations made in laboratory test machines with bearings of widely different sizes, for example, automotive wheel bearings vs. freight railroad anti-friction journal bearings.
3. A project has been set up with the objective of determining whether or not reliable information can be obtained regarding compatibility of greases by mixing two greases under various conditions in a mechanical worker and recording changes in cone penetrations.

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Unsaponifiable (Wool Grease Alcohols)	6% max.
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Free Fatty Acid (as oleic)	55-60%
Actual Free Fatty Acid Content	90%
Saponification No.	120-130
Free Inorganic Acid	0.2% max.
Iodine Value	20-40
Apparent Solidification Point (titre)	Approx. 44° C.
Softening Point	45-48° C.
% Sulfur	No corrosive sulfur

A.O.C.S. Methods

Patents and Developments

Improved Salt-Soap Greases

The production of complex soap greases containing conventional long chain fatty acid soaps in combination with low molecular weight salts already has been discussed in this column. In a recent patent issued to Standard Oil Development Co. (U. S. 2,610,947), it is pointed out that the practice has been to use naphthenic or aromatic lubricating oil bases in greases because of their high solvent power for soaps. Yet, the paraffinic oils are really more desirable due to their higher viscosity index, volatility for the same viscosity, oxidation resistance and high temperature stability.

According to the above patent, salt-soap thickened greases, which have good high temperature resistance, may be prepared by first forming a soap-salt concentrate in a relatively viscous aromatic type oil, say one of 250-1500 S.S.U. at 100° F. Thereafter, a substantial amount of a paraffinic oil is blended into the soap-salt concentrate at continued grease-cooking temperatures, such as 300°-350° F., thereby producing a stable grease of good high temperature properties.

If the paraffinic oil is added very gradually and at the cooking temperatures usually available in standard steam-heated grease kettles and worked mechanically while being stirred into the preformed thick grease or soap-salt concentrate, greases of good structure stability may be prepared. Paraffinic oils of 90-120 V.I., with viscosities of 200-500 S.S.U. at 100° F. are preferred. The dispersion of the soap-salt thickener may be greatly improved by drastic mechanical homogenization, as, for example, that obtained with a homogenizer of the Manton Gaulin type.

In general, about 2-20 parts by weight of C_{12}-C_{24} range fatty acids are first mixed with 20-50 parts of aromatic or naphthenic type mineral oil of high viscosity. About 1-15 parts of the other soap-salt constituent (low molecular weight carboxylic acid or aldehyde capable of undergoing the Cannizzaro reaction to form such an acid) is added to this mixture along with enough metal base to saponify the fatty acids and to combine with the acid or to undergo the Cannizzaro reaction with the aldehyde.

The mixture of ingredients then is heated to soap-cooking temperature (300°-350° F.) until the reactions are substantially complete and the water resulting has been evaporated. This results in a soap or soap-salt concentrate in relatively viscous aromatic or other non-paraffinic oil. Without lowering the temperature, 25-50 parts of a lower viscosity paraffinic oil then are blended in gradually, heat being applied to keep up the temperature and stirring being continued throughout the blending. Such a process produces a good product which may be further improved in texture and mechanical stability by extensive homogenization.

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Keto-Acid Soap Greases

It is known that lime soap greases are somewhat deficient at temperatures approaching or exceeding the boiling point of water, because such greases rely upon the presence of a small amount of water to maintain their true colloidal grease structure. If this water is evaporated, the greases become grainy, the oil separates from the soap, and failure of lubrication promptly ensues. To overcome this, a complex soap has been substituted for the conventional straight fatty acid soaps, whereby high temperature stability is claimed to have been improved. In U. S. patent 2,613,182, Standard Oil Development Company reports the discovery that greases made from keto acids of the long chain type (C_{12}-C_{22}) have outstanding high temperature properties.

Apparently the presence of the keto group stabilizes lime soap greases in the same manner that the presence of water stabilizes conventional lime base greases. However, the keto group is said to be unaffected by a rising temperature and the product remains stable when the conventional lime base greases would disintegrate upon evaporation of their normal water content. The proportions of soap to be used tend to run somewhat higher than those of conventional lime soaps, about 10-25% being preferred. The keto acids which are particularly suitable are 12-keto stearic acid, 4-keto stearic acid, etc.

Greases of High Mechanical Stability

One of the important characteristics of greases (particularly for use in ball bearings and mine loaders) is the ability of the composition to maintain its consistency over extended periods of rise. The relatively poor resistance of lithium stearate greases, for example, to changes in consistency, is claimed to be well known. Improvement to a marked degree can be effected by substituting in whole or in part the fatty acid soap by a soap of a hydroxy fatty acid such as 10- or 12-hydroxy stearic acid. But even these are claimed to be inadequate under extremely adverse conditions.

In U. S. patent 2,614,076, Shell Development Company describes the improvement in mechanical stability of greases gelled by hydroxy fatty acid lithium soaps, such as soaps of hydrogenated castor oil fatty acids. The effect is greatly improved by addition of a second alkali metal soap of a fatty acid having a carbon atom less than 9 carbon atoms removed from the carboxyl group which bears a substituent capable of forming a coordinate bond. Such an additive can be the lithium soap of an alkane hydroxyl monocarboxylic acid, soaps of monocycloaromatic hydroxy monocarboxylic acids, soaps of monoketoalkane monocarboxylic acids or monoaminoalkane monocarboxylic acids in which the keto or amino groups are attached to carbon atoms less than 9 carbon atoms removed from the carboxylic acid group, as well as similar mercapto compounds. It is preferred that amino alkane acids having 3-18 unbranched carbon atoms be employed, although this particular patent claims use of gamma hydroxy valeric acid for this purpose.

These stabilizing additives are added in an amount of 0.01-1% by weight. The soap content of the grease preferably is 6-15%. Table I gives the roll stability, as measured by the Shell Roll tester, of greases containing a turbine min-

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Manufacturers of Phthalocyanines that meet the requirements for lubricating greases as indicated in Industrial and Engineering Chemistry, Volume 44, Pages 556-563, 1952.

BLUE LUB - CODE P-4603

BLUE-GREEN LUB - CODE P-4653

GREEN LUB - CODE PG-4753

SUCO PHTHLOCYANINE PATENTS
U. S. Patents: 2,469,663
2,549,842
2,568,569
2,568,570

Attention is called to U. S. Patent No. 2,597,018 issued to Merker et al, not owned or licensed by Standard Ultramarine & Color Co.

Standard Ultramarine & Color Co.

HUNTINGTON, WEST VIRGINIA, U. S. A.

eral oil base thickened with 6% total lithium soaps (hydrogenated castor oil) and 0.25% stabilizing soap, unless otherwise indicated:

TABLE I

Additive (Lithium soap)	Roll Stability, Hours
None	100
Lactic acid (0.1%)	500
Alpha-hydroxy stearic acid	400
Beta-hydroxy propionic acid (0.1%)	270
Gamma-hydroxy valeric acid (0.1%)	> 1000
Delta-hydroxy valeric acid (0.1%)	440
6-Aminocaproic acid	300
4-Ketovaleric acid (0.1%)	> 500
Ortho-hydroxy benzoic acid	240
Meta-hydroxy benzoic acid	200
Mandelic acid	280
Ortho-nitrobenzoic acid	350
Ortho-aminobenzoic acid	400
Oxidized hydrocarbon acids	350
Petroleum hydroxy naphthenic acids	190

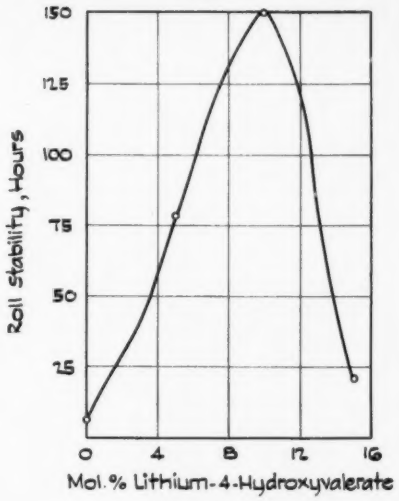
It will be observed that gamma hydroxy valeric acid soap gave the best stability.

In U. S. patent 2,614,077, Shell Development Company gives additional data on the use of similar stabilizers to lithium greases in general. The major soap in the preferred grease is a lithium soap of an aliphatic monocarboxylic acid having 10-24 carbon atoms and bearing no polar groups other than the carboxyl group. The minor soap is that of a monocarboxylic acid having 3-18 carbon atoms and bearing a hydrogen bonding substituent less than 9 carbon atoms removed from the carboxyl group. The normal amount of the minor soap must be between 4-12 mole per cent, preferably 5-10, based on the total soap content of the grease. The outstanding stabilizers appear to be the lithium soaps of 4-hydroxy and 4-keto valeric acids.

Figure I shows the effect of the concentration of such additives on the roll stability of lithium stearate greases. It

FIG. I

EFFECT OF ADDITIVE CONCENTRATION ON ROLL STABILITY OF LITHIUM STEARATE GREASE



will be observed that maximum effect is obtained with about 10 mole per cent of lithium 4-hydroxyvalerate.

Other Patents

Brit. Pat. 637,422 (Shell Refining & Marketing Co.)—Improved lithium grease of low penetration.

U. S. 2,610,768 (Tecalemit Ltd.)—Grease gun having reservoir cover and automatic locking means therefor.

U. S. 2,612,296 (Stewart-Warner Corp.) — Combined grease pump and reservoir.

U. S. 2,613,090 (Marles Bearing Co. Ltd.)—Grease shield for antifriction bearings.

U. S. 2,614,660 (House)—Covered spring greasing device.

U. S. 2,614,731 (White) — Power-driven lubricating apparatus.

U. S. 2,615,532 (Drury)—Air operated ball and roller bearing grease packer.

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NEW MEMBER

Anglo-Iranian Oil Company Joins

N L G I Company Representative

A native of London, England, H. T. Lorne, after graduating in chemistry from the Royal College of Science, London University, studied petroleum technology at the Royal School of Mines.

H. T. LORNE

A short period in the Research Laboratories at Sunbury, in 1935, of the Anglo-Iranian Oil Company, was followed by five years in the company's Abadan Refinery. Service with Anglo-Iranian was then interrupted for a three-year period in the Ministry of Supply during the war, after which Mr. Lorne returned to the Sunbury Research Station.

Prior to coming to the U.S.A. he was in charge of the Products Section at Sunbury and has now been in this country for one year in a technical capacity in the company's New York Office. Mr. Lorne is a member of the American Chemical Society and Society of Automotive Engineers, and is also active in several of the national petroleum societies.

N L G I Technical Committee Member

Dr. A. A. Rawlings, a native of Leeds, England, graduated in chemistry from Leeds University. He then carried out research work there and was awarded the degree of Doctor of Philosophy.

A. A. RAWLINGS

In 1936 he joined the Research Station of Anglo-Iranian Oil Company, Limited, and the following year transferred to the company's Abadan Refinery where he remained until the end of 1947.

Since that time, until his arrival in the U.S.A. at the end of September 1952 to take up a technical appointment in the A.I.O.C. New York office, he was a member of the Process Development Branch in London.

THE Anglo-Iranian Oil Company, with its subsidiary and associated companies, is one of the largest oil companies in the world. Its name—and its history—identify it with both the triumphs and the disappointments of Iran, but its activities for years have transcended any local application.

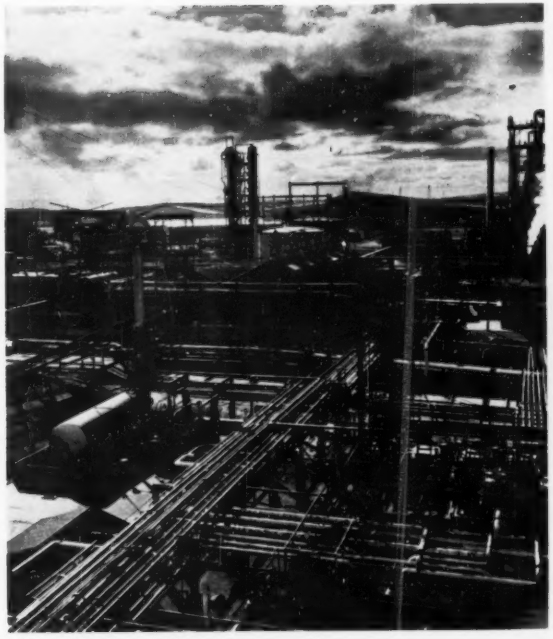
It all began with the inspirational forecast of the late W. K. D'Arcy, who negotiated the first concession to exploit oil in Iran in 1901—and who nevertheless had seven years of heartbreaking disappointment before he found it.

The great refinery at Abadan—later to be the biggest on earth—was completed in 1913, linked to the wells by a single pipe-line of 400,000 annual tons capacity — a pipe-line that when work stopped in 1951 had expanded to a net-

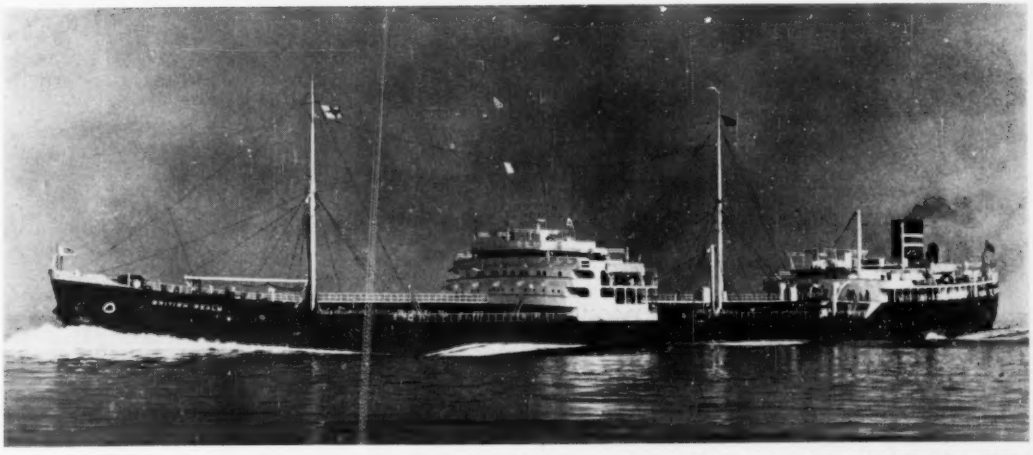
(Continued on page 36)

EXTENSIVE LABORATORIES at Anglo-Iranian's Research Station at Sunbury-on-Thames, near London, are shown in part.

BRITANNIC HOUSE, in Finsbury Circus, London, is headquarters of the Anglo-Iranian Oil Company.



A SECTION OF THE CRUDE OIL DISTILLATION AREA at Llandarcy refinery is shown. The Llandarcy refinery in South Wales, with a rated throughput of three million tons, is now producing over four million tons a year.



THE 28,000 TON BRITISH TANKER COMPANY'S OIL TANKER "BRITISH REALM" is seen during her trials off the Isle of Arran in Scotland.

A VIEW OF GRANGE MOUTH REFINERY shows construction of a vacuum unit, center, topping unit, left, and a catalytic cracker, right.

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work which could carry 35,000,000 tons.

From then on the story of A.I.O.C. is one of progress and expansion, frustrated at times by political argument in Iran, and in Iran at last brought to a stop.

But Anglo-Iranian's interests extend far beyond the frontiers of that historic land. It has further production sources in the Middle East, including Iraq and Kuwait. It even has an oilfield in England—at Eakring, in Nottinghamshire. It operates refineries in Britain, Australia, Belgium, France, Germany, Italy and Israel. Its distribution is handled in almost every clime. And—since the world's thirst for oil seems unquenchable—it is seeking more, through its subsidiary the D'Arcy Exploration Company, in Sicily, Nigeria, Trinidad, East Africa and Papua.

It has one of the largest privately owned tanker fleets in the world.

The Anglo-Iranian Oil Company has devoted almost continuous attention to research, an aspect of the oil industry which cannot be ignored. It has, over the years, built up an organization equipped to investigate every kind of problem relating to petroleum. Its research has enabled new and improved production and refining methods to be developed, new uses to be discovered for the numerous constituents of crude oil and the by-products of refining.

The company's main research station in the United Kingdom is at Sunbury, to the southwest of London. Since its inception in 1917, the story of research there has been one of continual growth, stimulated rather than handicapped by the second world war.

At Kirklington Hall, near the Nottingham oilfield, is a somewhat smaller establishment for research in prospecting methods and oilfield operation.

So the Anglo-Iranian Oil Company, with its associated enterprises, has grown up. Its birth, its development, its rise to its present position as one of the dominant groups in the world oil industry can perhaps be called something more than an outstanding story of modern commerce.

Anglo-Iranian's eventual annual contribution of well over 10,000,000 tons of home-refined petroleum products will be the biggest of any oil company to the United Kingdom's domestic economy.

PEOPLE in the Industry

George W. Jandacek Joins Deep Rock Oil Corp. Staff

George W. Jandacek has joined the staff of the Research and Development Department of Deep Rock Oil Corporation, it has been announced by N. K. Anderson, Director of Research and Development.

Mr. Jandacek will serve as a chemical engineer and will be stationed at Cushing, Oklahoma. A graduate of Northwestern University, he was employed by a petroleum engineering company in Chicago before joining Deep Rock.

Witco Vice-President Dies

Witco Chemical Company regrets to announce the death on December 21, 1952, of Thomas J. Starkie, vice-president, director, and member of the executive committee, and director of Witco Chemical Company, Ltd.

Mr. Starkie began his career in the chemical field with Harshaw Chemical Company and joined Witco in June, 1921. His club memberships included the Uptown Club, the Chemist's Club, the Salesman's Association of the American Chemical Society and the New York and National Paint Clubs.

Mr. Starkie was born in New York City, December 2, 1892. He is survived by his widow, Nellie Wright Starkie; a son, James M.; and a daughter, Elizabeth E. Starkie.

Deep Rock Promotes Austin to District Engineer

Kenneth O. Austin, Wichita Falls, Tex., has been promoted to district engineer of Deep Rock Oil Corporation's Texas district, it has been announced by H. R. Bolton, chief engineer of the production division.

Mr. Austin was in the company's waterflood operations program in Garnett, Kans., before being transferred to Texas in March of last year.

Dr. J. F. Haseman Joins Foote Mineral Staff

Foote Mineral Company announces the addition of Dr. J. F. Haseman to the Research and Development Staff at Berwyn, Pennsylvania. As group leader of the new Minerals Separation Division, Dr. Haseman will head a team consisting of a mineralogist, a chemist and a geologist. This new division will study the field of mineral separation and processing dealing with lithium ores and the various by-products of Foote's King's Mountain, N. C., and Sunbright, Va., operations.

A graduate of the University of Missouri, Dr. Haseman obtained his Master's degree from Cornell in 1938 and his Doctor's degree from Missouri in 1944. He was a Research Chemist with the Tennessee Valley Authority Wilson Dam, Alabama, from 1944 until joining Foote.

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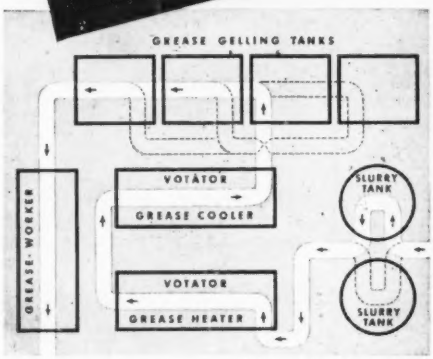

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The GIRDLER Corporation
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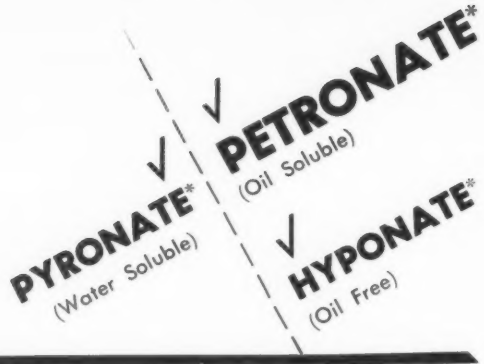

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Rainey Elliott Heads J & L Supply Company

The Jones & Laughlin Supply Company, Tulsa, Oklahoma, a wholly-owned subsidiary of Jones & Laughlin Steel Corporation, became a division of J&L on January 1, 1953, the corporation has announced.

On that date all of the assets of the J&L Supply Company, which serves the oil country with 88 stores throughout the western and southwestern part of the United States, were transferred to the parent corporation. The J&L Supply Company supplies tubular goods, pumping units, wire rope, and a complete line of oil country equipment to oil well drillers and oil producers in 18 states east of The Rockies, and in Alberta, Canada.

Canadian assets of the J&L Supply Company will be sold to the J&L Steel Sales Company, Ltd., a Canadian subsidiary, which will carry on the Canadian business previously conducted by the J&L Supply Company.

The newly-named Supply Division is headed by Rainey Elliott, Tulsa, who has been vice-president and director of the Supply Company. He will become general manager of the Supply Division.

John L. Shakely, Tulsa, president of the Supply Company, is retiring from active service after 39 years with the Supply Company and its predecessor, Frick-Reid Supply Corporation. He will remain with the Supply Division in a consulting capacity. Mr. Shakely is the newly-elected president of the Tulsa Chamber of Commerce.

These additional personnel changes also became effective January 1:

George L. Sutter, Tulsa, director of sales for the Supply Company since last August, became Assistant General Manager of the Supply Division.

Robert J. Woods, Jr., Tulsa, assistant director of sales of the Supply Company, became director of sales of the Supply Division.

Paul R. Warner, Tulsa, treasurer and credit manager of the Supply Company, became assistant treasurer and credit manager of J&L for the Supply Division.

Harold H. Wilson, Houston, Texas, a vice-president of the Supply Company, has become director, Gulf Coast operations of the Supply Division, with offices in Houston.

H. Lee Wilkins, Calgary, Alta., Canada, manager of Canadian operations of the Supply Company, has become Man-

ager, Jones & Laughlin Steel Sales Company, Ltd., Supply Division, with offices in Calgary.

The J&L Supply Division will continue to operate under the general supervision of A. J. Hazlett, J&L's executive vice-president—distribution.

Mr. Elliott joined the present organization in 1935 as a local store manager in Electra, Texas, for the Frick-Reid Supply Corporation. Subsequently he was a salesman in Turnertown and Dallas, Texas, and in 1941 was appointed sales manager. He remained in that position when the name of Frick-Reid was changed to J&L Supply Company in 1944.

On January 1, 1952, Mr. Elliott was named director of sales, and on August 1, he was elected vice-president and director of the Supply Company.

General Mills Chooses Directors of Fatty Acid Sales

Hugh A. Hamilton and Charles Greve have been named directors of fatty acid sales, Western Territory and Eastern Territory respectively, for the Chemical Division of General Mills, Sewall D. Andrews, Jr., division vice-president and general manager has announced. Both Mr. Hamilton and Mr. Greve will be stationed in the executive office in Minneapolis.

Mr. Hamilton joined General Mills in June, 1947, as technical director of the Chemoil Plant at Kankakee, Ill. He was moved to Minneapolis in March, 1951, where he has been in charge of fatty acid technical sales service.

Mr. Greve recently returned to General Mills after 21 months duty in Korea where he served as a major in the Corps of Engineers, acting as Senior Advisor in the G4 Plans Section of the Korean Military Advisory Group. He joined General Mills in 1946 as a salesman in the company's Chemical Division in Minneapolis.

Max A. Minnig Elected Vice-President of Sales

Max A. Minnig, vice-president of the Rubber Chemicals Division of Witco Chemical Company, has been elected by the directors of Continental Carbon Company and Continental Oil Black Company as vice-president in charge of sales for these two companies. Mr. Minnig has been associated with the Witco organization since January 1946.

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Industry NEWS

Research Increases Sales, Says Dr. Kimball, Midwest

Research is ringing up an ever-increasing number of sales dollars on the cash registers of industry and agriculture, Dr. Charles N. Kimball, president of Midwest Research Institute, told trustees of the organization at their eighth annual meeting in December.

Dr. Kimball cited examples of Institute activity which are showing up for clients on the profit side of the corporate ledger. "During the past year," he said, "the technical staff has developed a wide variety of new agricultural products, including insecticides and herbicides, and has perfected new grain processing and storage techniques. Additional industrial developments include food products, waxes from crude petroleum, temperature controls for home appliances, scientific equipment for use in hospitals, and materials for home and factory construction."

These programs were among the 265 projects for 156 different clients which accounted for research expenditures in 1952 of nearly a million and a quarter dollars . . . highest in the Institute's history.

The Institute head explained that expanding services to its clients have resulted in awareness, on the part of industry and agriculture, of Midwest's growth as an area center of technology. He described determination of the economic feasibility of new products, new processes and new enterprises as typical instances.

"Programs in our chemical engineering division alone," Dr. Kimball said, "have led to the construction of new plants, representing capital investment of 5 million dollars, which will employ some 600 people and gross an aggregate of 30 million dollars in annual sales." He added that the Institute also conducts similar operations in mechanical and electrical engineering, chemistry and physics.

Dr. Kimball discussed technical activities outside the Institute's laboratories as another factor in a highly successful year. He called it "in-plant" process engineering. Work of this type is aimed at increased yields, reduced production costs, and improvement of product quality, and is carried on in the plants of the clients. These studies include work in a range of industries from zinc smelters to fertilizers, from industrial chemicals to home appliances.

In connection with this scope of operation, Dr. Kimball disclosed that the Institute is also engaged in a comparatively new phase of scientific investigation . . . operations research. This method of study achieved prominence during World War II, when it was found that the scientific approach was applicable to non-technical as well as scientific problems.

"By studying industrial operating procedures, Midwest technical personnel is showing manufacturers and businessmen how they can make the most of what they have, in providing sounder bases for executive decisions," he explained. Typical examples are material handling problems for the milling and paper industries, and product transport scheduling for a major pipe line company.

With brief reference to the Institute's background, and the purposes for which it was established, Dr. Kimball forecast an even greater emphasis on serving the various elements of the nation's economy in the years ahead.

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Two Organizations Name Committees for 1953 IPE

Two of the outstanding organizations participating in the 1953 International Petroleum Exposition, the Scientific and Technical Committee and Nomads, have announced the names of the men who will be largely responsible for their activities during the oil show in Tulsa next spring.

G. H. Westby, chairman of the Scientific and Technical Committee, which is responsible for selecting exhibits to be displayed in the Hall of Science at the oil show, recently named the following industry technologists as chairmen of subcommittees: Geological — Philip Ingalls, associate editor of geology, The Oil and Gas Journal; Geophysical — W. T. Born, vice-president and laboratory director, Geophysical Research Corp.; Development and Engineering—(co-chairmen) Lloyd Elkins, production and research director, Stanolind Oil & Gas Co., and R. C. Earlougher, president, Earlougher Engineering Co.; Transportation — J. R. Polston, vice-president of operations, Service Pipe Line Co.; Refining—W. J. Carthaus, vice-president of manufacturing and research, Deep Rock Oil Corp.; Petrochemical — Miller W. Conn, manager of market development division, Phillips Petroleum Co.; Technical Films—Stanley W. Wilcox, director of public relations, Seismograph Service Corp.

Kent K. Kimball is again serving as executive secretary of the Scientific and Technical Committee. B. B. Weatherby, vice-president, Amerada Petroleum Corp.; Gustav Egloff, director of research, Universal Oil Products Co., and A. E. Ballin, president, Balco Engineering Co., are serving as consultants.

Mr. Westby and his committee will conduct a world-wide search for exhibits, displays, processes, equipment and scientific presentations that dramatize and demonstrate all phases of the petroleum industry's operations and progress, particularly in the past five years since the last exposition was held.

Co-chairmen have also been named from each of the five chapters of Nomads to head committees which will serve international delegates visiting the oil show in Tulsa.

The Nomads, an organization of men who sell oil equipment in foreign countries, will again serve as hosts to international delegates attending the oil show next spring.

Delegates from 43 nations attended the last exposition, held in 1948, and representation from at least 50 countries is predicted for the thirtieth anniversary 1953 show.

AIEE Meeting Features Petroleum Session

A session devoted to electrical applications in the petroleum field will be featured at the winter general meeting of the American Institute of Electrical Engineers at the Hotel Statler, January 19-23, H. F. Hickernell, technical session committee chairman, has announced. Some 4000 engineers and scientists are expected to attend the meeting.

The petroleum session, at which three papers will be presented and discussed, will be held on Wednesday, January 21 at 2 p.m.

Petroleum papers scheduled for presentation are: "Power Generation and Distribution in Petroleum Refineries," R. L. Lawrence and H. B. Thacker, Westinghouse Electric Corp.; "Use of Outdoor Switchgear in Petroleum Refineries", E. R. Hoyle, Sinclair Refining Co., and "Report on the Activities of the Electrical Equipment Subcommittee of the American Petroleum Institute—Refining Division", L. M. Goldsmith, Atlantic Refining Co.

The winter general meeting will be marked by 83 technical sessions and presentation of some 380 papers, in addition to conferences on management, education and basic concepts of the electrical art. It is expected to be the largest meeting of the institute since it was founded in 1884.

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Continental Can Reports Large Assets in Canada

Total assets of Continental Can Company, Inc., exceed $300,000,000, of which a substantial amount is in Canada, says Frank A. Whittall, president of Continental Can Company of Canada, Ltd., a wholly-owned subsidiary of Continental Can Company, Inc. In 1951, total sales for the company amounted to $460,595,487. Net earnings after income taxes and other charges set a new record in 1951 of $15,210,720. The company has over 28,000 holders of its common stock and more than 27,000 employees.

The company entered the Canadian can-manufacturing field in 1935 with the acquisition of the Whittall Can Company. It now has five installations in Canada — four metal can plants and one paper container plant. The latest addition is a new, $2,000,000 metal can plant at Burnaby, B. C., which will open early next year.

In Canada, complete research facilities for the company are located at the St. Laurent plant, near Montreal.

In Canada, the United States and Cuba, the company operates a total of 64 plants. These include 39 metal container plants, nine paper container and fibre drum plants, a paper mill, three crown and cork plants, four machine shops and three defense plants. Sales offices are located in the principal cities of Canada, the United States and Cuba.

Witco Issues Bulletin Describing Stearate Line

A 32-page technical service bulletin describing the complete line of Witco Chemical Company stearates and their uses and properties is now available upon request.

All stearates manufactured in Witco's Chicago and Brooklyn plants, including aluminum, cadmium, calcium, lead, lithium, magnesium, sodium and zinc stearates as well as special soaps, are discussed in detail.

The various industries in which these compounds find applications and the characteristics of the compounds which fit them for each application are covered both generally and specifically.

The government specifications of metallic stearates as to grade, specification number and uses are listed. Also given are the analytical tests used, a guide to Witco's other products and the industries using them, and a list of the technical service reports which relate to Witco's stearates and special soaps.

For copies of bulletin 53-1, write to Witco Chemical Company, 295 Madison Avenue, New York 17, New York, on company letterhead.

Alemite Division Introduces New Automotive Chemical

A new automotive chemical product has just been announced by the Alemite Division of Stewart-Warner Corporation.

This new product makes all internal combustion engines perform more smoothly, last longer, and run more economically, according to Gus Treffeisen, Alemite distribution sales manager. The division claims its action in an engine assures free-acting valve stems, hydraulic valve-lifters, piston rings, etc., in addition to thoroughly cleaning the engine of destructive foreign matter and by-products of combustion.

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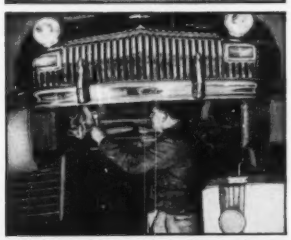

FUTURE MEETINGS of The Industry

JANUARY, 1953

19-23 American Inst. of Electrical Engineers (winter general meeting), Hotel Statler, New York, N. Y.

FEBRUARY, 1953

1-6 American Socy. for Testing Materials (Com. D-2 on petroleum products and lubricants), Hotel Cleveland, Cleveland, O.

3-5 American Socy. for Testing Materials (A-1 on Steel), Birmingham, Ala.

5-7 Missouri Petroleum Assn. (annual convention), Hotel President, Kansas City, Mo.

12-13 Western Petroleum Refiners Assn. (regional meeting), Beaumont Hotel, Beaumont, Tex.

13 American Socy. for Testing Materials (Philadelphia District — National Officer's Night), Philadelphia, Pa.

16-18 American Petroleum Institute (Division of Marketing, Lubrication Committee meeting), Sheraton-Cadillac, Detroit, Mich.

18-19 Iowa Independent Oil Jobbers Assn. (annual convention), The Savery, Des Moines, Ia.

25-26 Wisconsin Petroleum Association, Hotel Schroeder, Milwaukee, Wisc.

26 to Mar. 1 Pacific Automotive Show, Civic Auditorium, San Francisco, Calif.

MARCH, 1953

2-6 American Socy. for Testing Materials (spring meeting), Hotel Statler, Detroit, Mich.

3-5 Socy. of Automotive Engineers, National Passenger Car, Body, and Materials Meeting, Sheraton-Cadillac, Detroit, Mich.

4-6 American Petroleum Institute (Division of Production, Southwestern District spring meeting), Hilton Hotel, Ft. Worth, Tex.

8-11 American Inst. of Chemical Engineers, The Buena Vista, Biloxi, Miss.

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2. Remember our anniversary
"WITH A NEW YEAR'S RESOLUTION AND THIS STRING ON MY FINGER-- I WON'T FORGET TO HAVE MY CAR LUBRICATED EVERY 1,000 MILES!"

9-11 Mfrs. Standardization Socy. of Valve and Fittings Industry, Hotel Commodore, New York, N. Y.

10-12 Illinois Petroleum Marketers Assn. (annual convention), Hotel Sherman, Chicago, Ill.

15-19 American Chemical Society (123rd national meeting), Hotels Biltmore and Statler, Los Angeles, Calif.

15-19 American Institute of Mining and Metallurgical Engineers (annual joint meeting of petroleum metals, and mining branches), Statler Hotel, Los Angeles, Calif.

16-20 National Assn. of Corrosion Engineers (1953 conference and exhibition), Hotel Sherman, Chicago, Ill.

17-19 Ohio Petroleum Marketers Assn. (annual convention and exposition), Deshler-Wallick, Columbus, Ohio.

18-20 American Petroleum Institute (Division of Production, Mid-Continent District spring meeting), Mayo Hotel, Tulsa, Okla.

19-21 Texas Oil Jobbers Assn. Inc. (annual convention), The Plaza Hotel, San Antonio, Tex.

23-25 Western Petroleum Refiners Assn. (annual meeting), Plaza Hotel, San Antonio, Tex.

23-26 American Assn. of Petroleum Geologists—Socy. of Economics Paleontologists and Mineralogists —Socy. of Exploration Geophysicists (joint annual meeting), Coliseum, Houston, Tex.

24-27 Greater New York Safety Council (23rd annual safety convention and exposition), Hotel Statler, New York, N. Y.

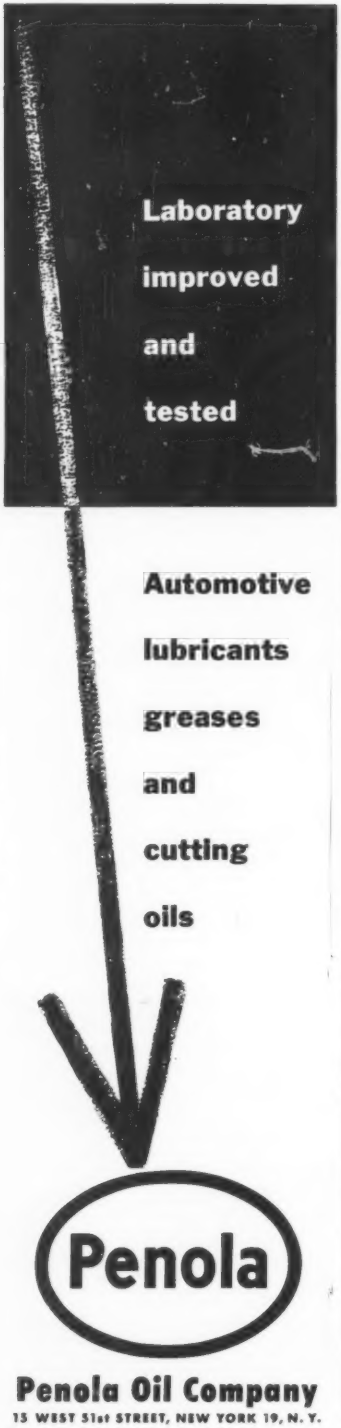
25-27 Socy. of Automotive Engineers (national production meeting), Hotel Statler, Cleveland, Ohio.

28 North Texas Oil & Gas Assn. (annual meeting), Kemp Hotel, Wichita Falls, Tex.

30-31 Texas Independent Producers & Royalty Owners Assn. (7th annual meeting), Gunter Hotel, San Antonio, Tex.

APRIL, 1953

8-10 American Petroleum Institute (Division of Production, Eastern District spring meeting), Hotel William Penn, Pittsburgh, Pa.



FUTURE MEETINGS

APRIL, 1953

13-15 American Socy. of Lubrication Engineers (annual meeting and exhibit), Hotel Statler, Boston, Mass.

13-15 Assn. of Nebraska Liquefied Petroleum Gas Dealers (annual convention), Hotel Fontenelle, Omaha, Neb.

15-17 National Petroleum Association (semi-annual meeting), Hotel Cleveland, Cleveland, Ohio.

16-19 National Tank Truck Carriers Inc., Boca Raton Hotel, Boca Raton, Fla.

20-22 American Petroleum Institute (Division of Transportation, products pipeline conference), Hotel Muehlebach, Kansas City, Mo.

26-29 American Inst. of Chemical Engineers (joint meeting with Chemical Institute of Canada), Royal York Hotel, Toronto, Canada.

27-28 Independent Petroleum Assn. of America (midyear meeting), Jefferson Hotel, St. Louis, Mo.

MAY, 1953

4-5 American Petroleum Institute (Division of Marketing, midyear meeting), Baker Hotel, Dallas, Tex.

4-6 Liquefied Petroleum Gas. Assn. (annual convention & trade show), Conrad Hilton Hotel, Chicago, Ill.

7-8 American Petroleum Institute (Division of Production, Rocky Mountain District spring meeting), Gladstone Hotel, Casper, Wyo.

10-12 tentative Pennsylvania Petroleum Assn., Inc. (3-day meeting), Bedford Springs Hotel, Bedford Springs, Pa.

11-13 American Petroleum Institute (Division of Marketing, Lubrication Committee meeting), Greenbrier, White Sulphur Springs, West Va.

11-14 American Petroleum Institute (Division of Refining, 18th midyear meeting), Hotel Commodore, New York, N. Y.

11-15 National Fire Protection Assn. (annual meeting), Edgewater Beach Hotel, Chicago, Ill.

14-23 International Petroleum Exposition, Tulsa, Okla.

17-19 Empire State Petroleum Assn., The Roosevelt, New York, N. Y.

28-29 Western Petroleum Refiners Assn. (regional meeting), Broadview Hotel, Wichita, Kans.

JUNE, 1953

2-3 American Petroleum Institute (Division of Production, Pacific Coast District spring meeting), Hotel Statler, Los Angeles, Calif.

4-5 Kentucky Oil & Gas Assn. (annual meeting), Lafayette Hotel, Lexington, Ky.

7-12 Socy. of Automotive Engineers (summer meeting), The Ambassador and Ritz-Carlton, Atlantic City, N. J.

15-19 American Petroleum Institute (Division of Production, midyear committee conference), Hotel William Penn, Pittsburgh, Pa.

18-19 Pennsylvania Grade Crude Oil Assn. (annual meeting), William Penn Hotel, Pittsburgh, Pa.

18-19 Western Petroleum Refiners Assn. (regional meeting), Conrad Hilton Hotel, Chicago, Ill.

28 to July 2 Petroleum Equipment Suppliers Assn. (annual meeting), Broadmoor Hotel, Colorado Springs, Colo.

29 to July 3 American Socy. for Testing Materials (annual meeting), Chalfonte-Haddon Hall, Atlantic City, N. J.

AUGUST, 1953

17-19 Socy. of Automotive Engineers (national West Coast meeting), Georgia Hotel, Vancouver, B. C., Canada.

SEPTEMBER, 1953

6-11 American Chemical Society (124th national meeting), Conrad Hilton Hotel, Chicago, Ill.

13-16 American Inst. of Chemical Engineers, Fairmont and Mark Hopkins Hotels, San Francisco, Calif.

14-17 Socy. of Automotive Engineers (National Tractor Meeting and Production Forum), Schroeder Hotel, Milwaukee, Wis.

16 American Petroleum Institute (Division of Marketing, Lubrication Committee meeting), The Traymore, Atlantic City, N. J.

16-18 National Petroleum Assn. (51st annual meeting), The Traymore, Atlantic City, N. J.

21-23 American Trade Assn. Executives (annual meeting), Chalfonte-Haddon Hall, Atlantic City, N. J.

24-25 Western Petroleum Refiners Assn. (regional meeting), Henning Hotel, Casper, Wyo.

27-29 National Assn. of Oil Equipment Jobbers (annual meeting), Neil House, Columbus, Ohio.

29 to Oct. 3 Socy. of Automotive Engineers (national aeronautic meeting), Statler Hotel, Los Angeles, Calif.

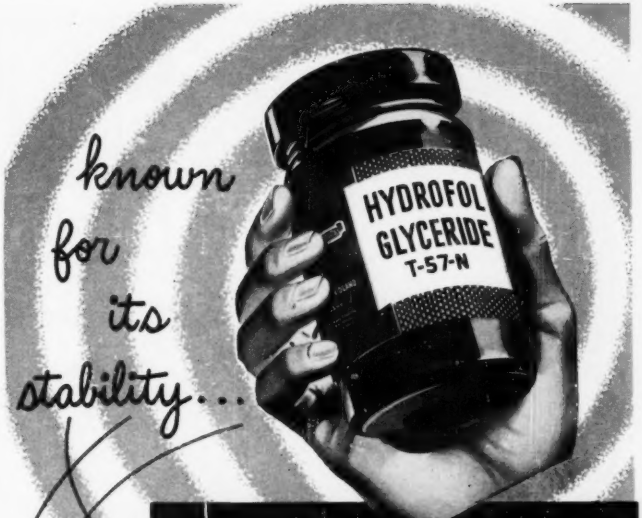
OCTOBER, 1953

15-16 Petroleum Marketers Assn. of Texas (annual meeting), Adolphus Hotel, Dallas, Tex.

19-20 Independent Petroleum Assn. of America (annual meeting), Hotel Texas, Ft. Worth, Tex.

19-23 National Safety Congress, Conrad Hilton, Congress, Morrison, Sheraton, Chicago, Ill.

26-28 National Lubricating Grease Institute, Annual Meeting, Edgewater Beach Hotel, Chicago, Illinois.



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Saponification Number	**193 to 198**
Iodine Number	**1.0 Maximum**
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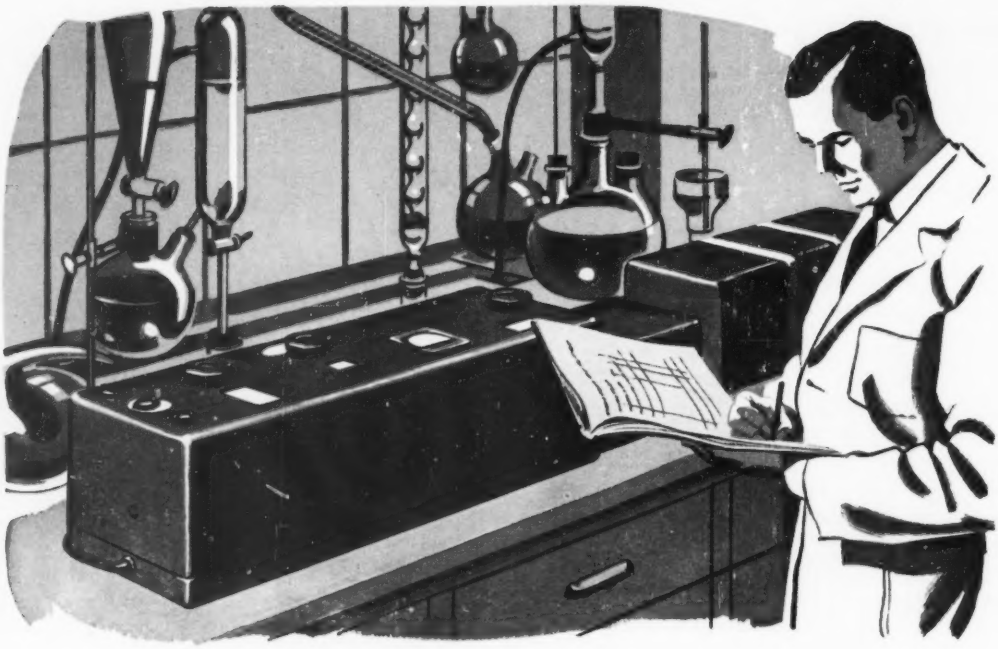

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*Address*_____

*City*_____ *Zone*____ *State*____

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Branch Offices:
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221 N. LaSalle St., Chicago 1, Ill.
420 Market St., San Francisco 11, Calif.

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Foote Mineral Company
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Representative—H. C. Meyer, Jr.

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Chemical Division
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Representative—Sewall D. Andrews

A. Gross and Company
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P. O. Drawer 110
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Representative—W. G. McLeod

Harshaw Chemical Company
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Representative—W. J. Straka

Leffingwell Chemical Company
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Whittier, California
Representative—D. E. Murphy

The Lubrizol Corporation
Euclid Station
Box 3057
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Representative—John H. Baird

Mallinckrodt Chemical Works
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Representative—C. E. Cosby

N. I. Malmstrom & Company
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Brooklyn 22, New York
Representative—Ivar Wm. Malmstrom

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Metalley Corporation
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Representative—Walter M. Fenton

Metasap Chemical Corporation
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Monsanto Chemical Company
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New York 5, New York
Representative—Alex Stewart

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Synthetic Products Company
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Warwick Chemical Company
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Continental Can Company, Inc.
1107 Waldheim Building
Kansas City 6, Missouri
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324 North Fifteenth Street
Milwaukee 1, Wisconsin
Representative—Willard J. Flint

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Chicago 38, Illinois
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J. & L. Steel Corp.
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New York 17, New York
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National Steel Container Corporation
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Representative—Henry Rudy

The Ohio Corrugating Co.
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570 Lexington Avenue
New York 22, New York
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Cincinnati 9, Ohio
Representative—Richard P. Field

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60 Northeast 11th Avenue
Minneapolis 13, Minnesota
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5701 Natural Bridge Avenue
St. Louis 20, Missouri
Representative—G. A. Hubbard

Stewart-Warner Corporation
Alemite Division
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Chicago 14, Illinois
Representative—Walter Duncan

United States Air Compressor Company
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Representative—David F. O'Keefe

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Freedom Valvoline Oil Company
Box G
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Representative—D. A. Smith

Mid-Continent Petroleum Corporation
Mid-Continent Building
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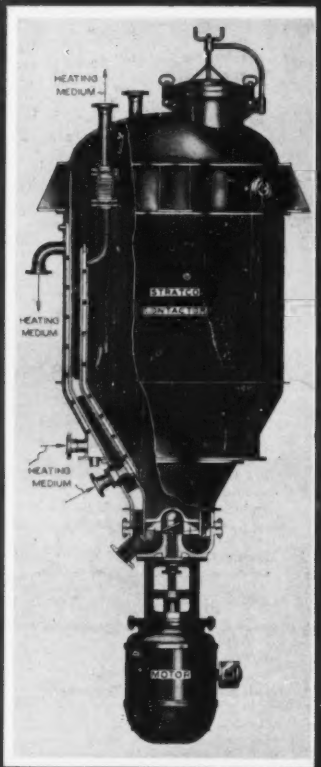

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